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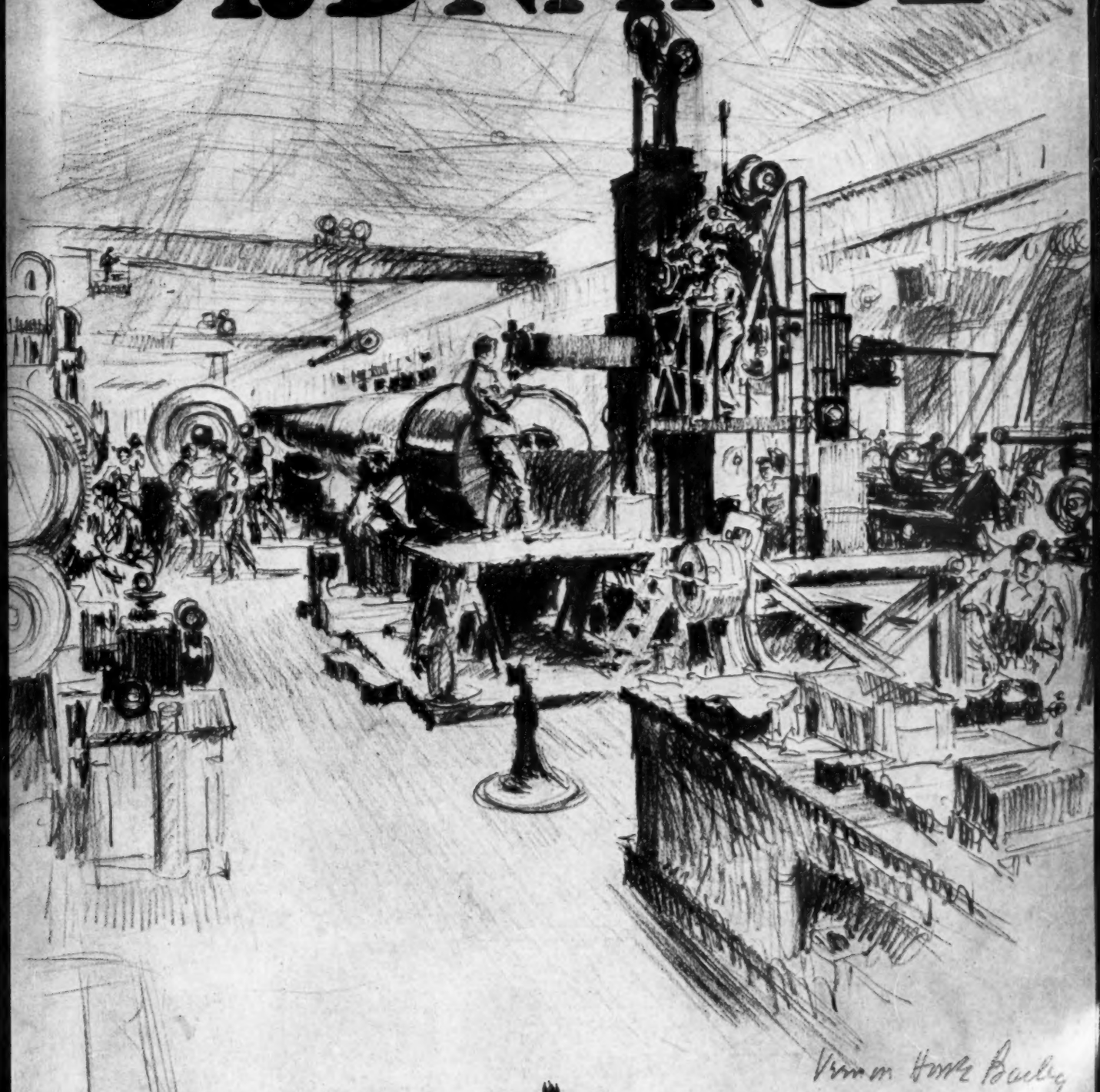

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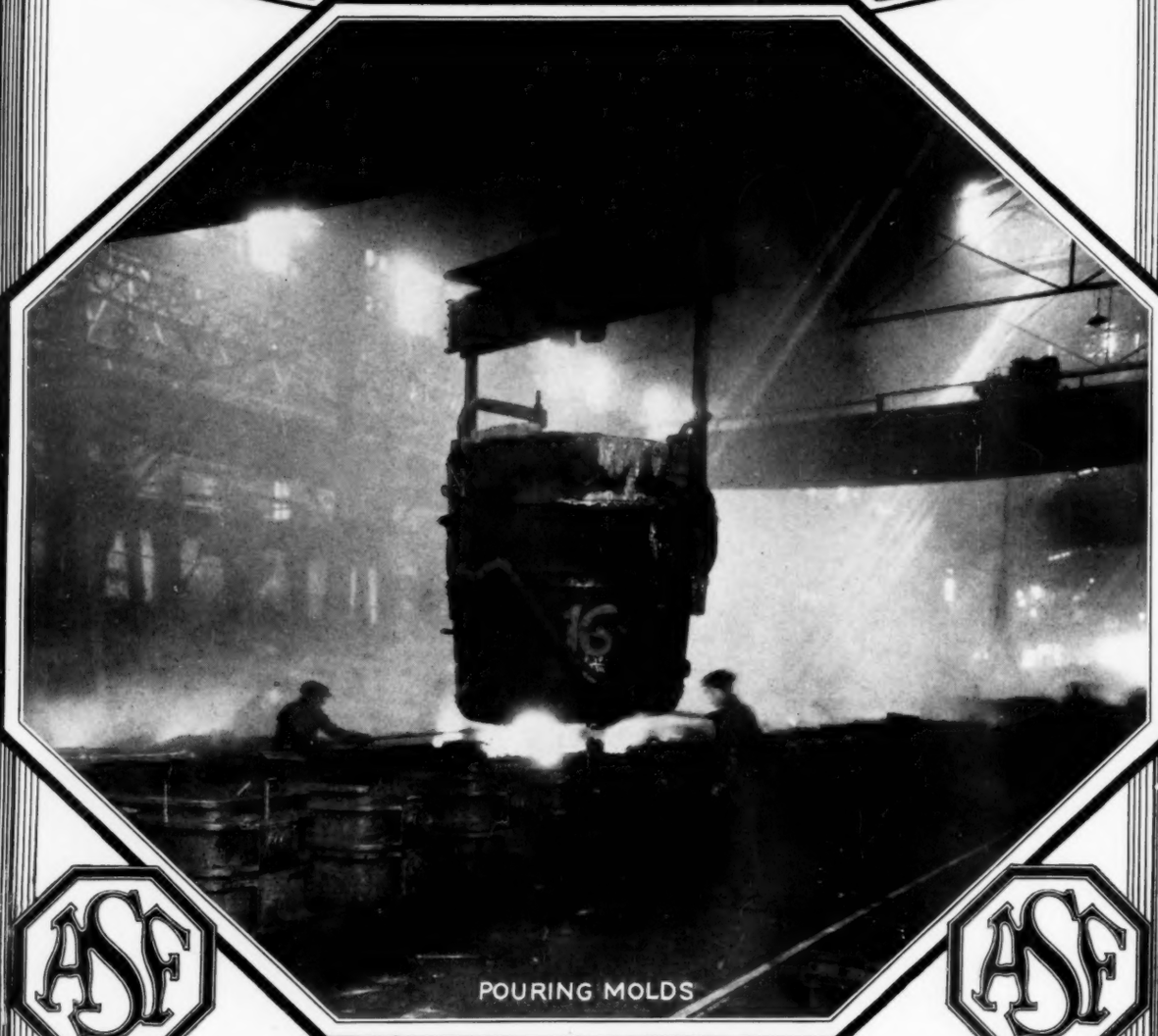

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ARMY ORDNANCE

The Journal of the Army Ordnance Association

Pledged to Public Service in Effecting Industrial Preparedness for War as Our Strongest Guarantee of Peace

Published by the Army Ordnance Association, The Mills Building, Washington, D. C. L. A. Codd, Editor.

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Frederick Huff Payne, The Assistant Secretary of War

Industrialist and Financier; Assistant District Chief, Bridgeport Ordnance District; Lieutenant Colonel, Ordnance Reserve Corps; Charter Member, Army Ordnance Association; Appointed The Assistant Secretary of War in Charge of Industrial Mobilization, April 22, 1930.

ARMY ORDNANCE

VOL. X MAY-JUNE, 1930 No. 60

The Services of Supply

The American Record Overseas, 1917-1918

By J. G. Harbord*

A YEAR ago General Connor was good enough to invite me to speak to the Army War College class of my year's experience as Chief of Staff of the American Expeditionary Forces. I am appearing[1] before you today because he has asked me to extend the narrative to include my 10 months in command of the Services of Supply. The history of these 10 months is the chronicle of an effort which at its high tide involved the command of 668,000 men and over 40,000 civilian laborers, administered in 11 territorial sections, reaching from England to Italy and back across France to Antwerp, with a staff of over 2,000 officers at its headquarters at Tours, which operated in 19 staff departments and services and which canceled $200,000,000 in contracts within 36 hours after the Armistice. I have leaned heavily on the official records in compiling the story. I have a suspicion that it is perhaps the first time that some of my official reports have ever been quoted.

My year as Chief of Staff ended on May 5, 1918, when I was relieved by Maj. Gen. James W. McAndrew, destined four years later to end his outstanding career as commandant of the Army War College, an untimely death and a great loss to our country.

On my relief I joined the Marine Brigade of the Second Division. After two months my promotion brought me the command of the Second Division, which I assumed on July 14 and held for two brief weeks. The last days of July found the division in rest at and around the little village of Nanteuil-les-Haudain, about a dozen miles north of Meaux. It had been almost continuously in action since June 1 near Chateau-Thierry, and had lost heavily in the battles of July 18 and 19, which you will remember as the Soissons offensive. It was now receiving replacements and generally refitting for its part in the next American offensive.

I WAS at luncheon with my general staff and aides in the modest Chauteau of Droiselles on the afternoon of July 26 when a telephone message directed me to report without delay to the commander-in-chief at Chaumont. With Capt. Fielding S. Robinson, my marine aide, I left within the hour with considerable wonder as to the purpose of my summons. We rolled down into the historic valley of the Marne—that holy land of the French arms—through Meaux and La Ferte, familiar scenes, no doubt, to some of you, up to the Seine to Troyes, and on through Bar-sur-Aube, reaching Chaumont by 10 that night. Still more or less keyed up from the strain and responsibilities of the Soissons battle, it seemed to me not unlikely that, taking advantage of the inactivity of the moment, the general was calling me to Chaumont to take back his congratulations and greetings to the Second Division.

The general and his immediate staff were quartered in that beautiful old chauteau a few miles south of Chaumont on the Marne Valley highway to Langres. The adjutant general, Robert C. Davis, met me in the lower hall and told me the chief was waiting to discuss a very important matter with me, and that I would find him in his room. As I ascended the steps I realized that perhaps I had been called to make that long drive under a summer sun for something more than kind words, and that we were still at war. The commander-in-chief lost no time coming to the matter which was on his mind.

He had, he said, been intending for some time to make a change in the command of the Services of Supply. He had just received a letter from the Secretary of War announcing an intention to send General Kernan, then commanding the Supply Services, for duty in Switzerland. Further, that it had been suggested to him that Gen. George W. Goethals, then Director of Purchase, Storage and Traffic under the Chief of Staff, should be sent to France to succeed General Kernan, reporting direct to the War Department instead of through General Pershing. This would take from the latter his control over the supply of his command and establish a coördinate authority in the American Expeditionary Forces. The Secretary of War requested General Pershing's views in the premises. From the latter's comment that July night on the fatal consequences certain to result from such an arrangement I have yet to hear dissent from the lips of any professional soldier.

General Pershing said that as I had been Chief of Staff during the organization period of the American Expeditionary Forces, and had commanded the Second Division during its recent activities, he felt that a suggestion of myself to relieve General Kernan might be acceptable to the authorities in Washington and avert action which he believed invited disaster.

The general undoubtedly realized what it meant to surrender command of a victorious division and turn my face to the rear, for he was good enough to appear to rest his action on my consent. I said a few words that were intended to recognize my obligation to him for having brought me to France, with the great opportunities that had followed, and to signify my readiness to go anywhere that he

---

*Chairman, Radio Corporation of America. Chief of Staff, A. E. F., in France, May 14, 1917-May 5, 1918; commanding Marine Brigade near Chateau-Thierry, June-July, 1918; commanding 2nd Division in Soissons offensive, July 18, 19, 20, 1918; commanding Services of Supply, July 29, 1918-May 26, 1919; reappointed Chief of Staff, A. E. F., May 26, 1919; Deputy Chief of Staff, U. S. A., July 1, 1921-December 29, 1922. Major General, U. S. Army, Retired.

[1]This article was given by General Harbord as an address to the students of the Army War College, March 14, 1930. It is published in ARMY ORDNANCE with the permission of the author and the approval of the Commandant of the War College.—Ed.

wished. He reserved final decision for the next morning, and when I reported at the office and confirmed my position of the night before he issued orders effective at once. He was good enough to cheer me with an offer to return me to combat troops when I should have trained a successor in the S. O. S. But the next combat unit I commanded was the reorganized Second Division at Camp Travis, Tex., in 1920.

The orders called for me to report to the Commander-in-Chief at Tours, the headquarters of the Services of Supply, on Monday, July 29, it being then the 27th. I left at once for the Second Division and turned over the command to General Lejeune, the senior brigade commander. A division commander in war has a modest personal retinue. I lined up the chauffeur, the orderly, the French cook, the interpreter, and my two aides-de-camp, and told them I was leaving the front and would free them from any obligation to follow me. Their answer was "Where you go we go." I joined General Pershing at Tours on the morning of July 29, assumed command as ordered, and left that night with him for an inspection of the base ports.

THE distance of 3,000 miles from our shores, the growing submarine menace, the unknown available tonnage, and the uncertainty as to where we would operate in France, all these had at its inception in the summer of 1917 complicated our supply situation to a degree greater than any other in our history.

The channel ports and the railroads of northern France were congested by British and French traffic. The Mediterranean ports, 900 miles farther from America, were in waters less protected from submarines than the open Atlantic. Our selection was thus limited to the Atlantic ports south of Brest, a port unsuited to freight discharge, and still reserved for naval uses. By early 1918 it was evident that the Atlantic ports were inadequate, and arrangements were made to use Mediterranean ports in spite of the longer haul and the greater danger. Time justified this action for we actually lost no ships by submarines in the Mediterranean.

The relation of the railroads to the front was vital to our choice. From the ports of western France there were available railroad lines to the northeast, including double-track lines from Bordeaux and St. Nazaire forming a junction near Bourges, thence running north and east beyond Dijon, with radiations towards Epinal and Nancy. It was estimated that these lines, with collateral lines, could handle for American uses perhaps 50,000 tons per day. These reasons led to the selection of St. Nazaire, La Pallice and Bassens for permanent ports, with Nantes, Bordeaux and Pauillac for emergency use. Several smaller ports, such as St. Malo, Sables d'Olonne and Bayonne, were used chiefly for unloading coal, and from time to time ships were sent to Cherbourg and Le Havre. Brest later became our greatest passenger port.

The supply service of the American Expeditionary Forces had been organized in the summer of 1917 under the old name of line of communications. It had not only to deal with procurement and supplies from across 3,000 miles of ocean, and their storage on foreign soil, but was under the additional necessity of obtaining every possible ounce of supplies to be had from Europe. More than this, account had to be taken of the distance from seaboard to fighting front; of available sites for the gigantic installations that were inevitable; of dock facilities; and other requirements unusual in our military experience.

It was at once necessary to know the reserve of supplies of all kinds for which storage was to be provided. Considering distance from home, scarcity of tonnage, and the submarine peril, 90 days for the maximum strength of the American Expeditionary Forces was taken as the minimum consistent with safety. This was never quite half attained, and in August, 1918, was changed to 45 to be distributed as the 90—half at the base ports, one-third in intermediate storage, and a sixth in advanced storage. When our ideas of force expanded from 2,000,000 to 4,000,000, it was good military bookkeeping to change from 90 to 45 days.

The President had laid down the principle of coöperation with the British on the sea and with the French on land. The application of this really left with the latter the right of suggestion as to where the American forces would be used. The British thought we should be used in the line between them and the French, urging the convenience of a common tongue. The first French suggestion, based possibly upon some doubt as to our efficiency, was to send us to farthest Alsace, where there was little promise of activity.

Our own studies of strategy of the situation called for our employment in the region south of Metz, lying between the Meuse and the Moselle. Such concentration would threaten the great iron district of Briey and menace the German railroads running behind and parallel to their front. Every military student we had was more or less familiar with Griepenkerl, and had fought over that region in map problems for years, knowing its topography and place names better than some parts of our own country. Our First Division reached Gondrecourt in early July, and that generally indicated the location of others as they should arrive. This was convenient to the region described and was satisfactory to the commander-in-chief. Our line of communications must roughly align itself between the western ports of France and our training areas near the Vosges Mountains, an average distance of 500 miles.

The problem was at once presented as to the disposition of our 90 days' reserve. Should it be kept near the seaboard in base storage, being forwarded as needed? Should it be all forwarded to the vicinity of the troops, thus avoiding an expensive second handling at the ports and be kept in advanced storage? Forces on the western front were quite evenly balanced in 1917; the possibility of an enemy offensive from any one of several directions had to be considered. Thus it would be unwise to store all our supplies immediately behind our own lines. The possibility of interruption to rail traffic by storms, attacks from the air, and destruction of bridges, as well as congestion by the development of new theaters of activity, made it imprudent to leave the bulk of our supplies near the seaboard, limiting that near the troops to their daily necessities.

These considerations determined the distribution of supplies into base, intermediate and advanced storage. This distribution with half the storage at the base would give us our supplies echeloned in depth, and ready to be shipped with equal facility to various portions of the Allied front, eliminating back and cross railroad hauls.

Many conditions affected the location of intermediate storage. It must not be too far to the front, limiting its efficiency if troops it was to supply were shifted to east,

Drawn for Army Ordnance by Capt. J. D. McIntyre, Ord. Dept., U. S. A.

Principal Supply Depots of the A. E. F. in France, 1917-1918.

west, or north; it must be near important rail junctions permitting more than one line to the front in case of accidents; it must be far enough to make the railroad haul from the seaboard one of economoy not involving a second handling of millions of pounds of freight for a disproportionately short haul. There were further considerations, such as streams of water, topography suitable for great installations, female labor, power supply, available sites not needed by the French, and generally the convenience of that fighting but meticulous race. Certain rail lines were not available to us. Some parallel to the fighting front must not be crossed by more than a certain number of trains each 24 hours.

THESE factors determined the location of the principal intermediate storage depot which was placed at Gievres. It was on the main line of railroad from St. Nazaire through Tours toward Dijon, the ancient seat of the Dukes of Burgundy. This was the city from which Charles the Bold sallied forth to die in the marshes in front of Nancy six years before Columbus made possible American participation in the World War.

At Gray and Is-sur-Tille there were in existence railroad regulating stations which served the eastern portion of the western front. To enable it to continue to serve the French and to take over the duty of distributing supplies to our training areas, Is-sur-Tille was enlarged. This place was selected, therefore, for the principal advanced storage. It was here that by his smooth and efficient administration of this great regulating station, jointly with the French, the regulating officer, Col. M. R. Hilgard, performed one of the difficult and important tasks of the American Expeditionary Forces.

Signal Corps Photo.

220-mm. French Guns Ready for Transfer to American Troops, St. Nazaire, France, April 7, 1918

When work was begun at Gievres it was soon evident that if the war lasted long, Bordeaux with the Bassens docks and the completed port at Talmont, would become more important than St. Nazaire which, from its construction, had limitations. It seemed prudent, to divide the intermediate storage instead of having it all in one place where raids from the air might bring wholesale destruction. A twin installation for Gievres was planned at Montierchaume, near Chateauroux, on the main line leading from Bordeaux to the road connecting St. Nazaire and Is-sur-Tille.

Time justified the choice of the location of Gievres, for it could admirably serve any part of the western front. It supplied directly the divisions operating before Paris when it was threatened in July, 1918. The installation was the largest of its kind in the American Expeditionary Forces, the ground covered being 6 miles in length and 2 miles in width. It contained when finished, 143 miles of standard gauge track, 45 miles in the seven receiving, classification, and departure yards; 7 miles in the tracks serving the locomotive and engine terminal facilities; 13 miles for engineer depot storage; 9 miles eastbound main line freight track, and the balance, 69 miles, at the 165 warehouses assigned to the various services. Eighty-five locomotives per day were turned within the engine terminal, and 2,300 cars per day were handled.

This giant installation was born of the vision of Col. William J. Wilgus, deputy director general of transportation of the American Expeditionary Forces. Here over twenty thousand troops under Col. Charles J. Symmonds guarded and stimulated the great heart of the Services of Supply. It beat in cadence to his able leadership.

Similar projects and yards, but somewhat smaller, were erected at St. Sulpice, Is-sur-Tille and Montoir. The twin of Gievres at Montierchaume was never completed. Advance depots were planned in the advanced section north of Dijon and in the neighborhood of Chaumont to serve our most probable theater of activity. These directly served our Army when we operated northeast of Paris in the closing days of the war.

WHEN I assumed command of the Services of Supply I inherited the organization that I used, with few important changes in name, to the end of my tour there, and I retained the efficient Chief of Staff, Gen. Johnson Hagood. Starting out as a line of communications in Paris in August, 1917, with base ports under an assistant chief of staff representing a distant commander in chief, as called for by the prewar field service regulation, that system had failed.

The administration, discipline, and supply in any defined territorial area are too intimately connected to be handled by independent agencies. To have a section commander responsible for these, and certain other functions handled by an assistant chief of staff, proved impracticable. These activities were soon united under the section commanders, who in time numbered 11, commanding nine base, one intermediate, and one advanced section. In February, 1918, the line of communications was reorganized under the name by which we are considering it. By this time the direct access of over 20 independent staff agencies had become a serious burden on the time of the commander-in-chief. Accordingly, all staff services and departments of the American Expeditionary Forces, except the Adjutant General's, the Inspector General's and the Judge Advocate General's Departments, were now to be grouped under one coördinating head, the Commanding General, Services of Supply. A general staff, paralleling, so far as necessary, that at general headquarters, was organized by him.

By the end of March the physical grouping of the supply chiefs had taken place at Tours, where General Kernan had taken his headquarters from Paris the previous January. The title of commanding general, and the trappings of command characterized the office of the coördinator, but some essentials of command were lacking. Within that month Marshal Foch, himself, in front of Amiens, was to find that one might coördinate but not quite command. Chiefs of the great supply departments still looked beyond Tours to the commander-in-chief, whose staff officers they nominally continued to be until the American Expeditionary

Signal Corps Photo.

Acres of Trucks and Other Equipment Awaiting Shipment, Gievres Intermediate Depot, France, January, 1919.

Forces passed into history. Their service requirements, independently formulated, were forwarded for action at general headquarters, bearing no more evidence of actual authority than that usually imparted by a chief of staff or adjutant general in the correction of minor inconsistencies and clerical errors.

Circumstances were principally to blame if the old-time line of communications, largely bound about by the little pre-war field service regulations, and the ideas of another day, had undergone a change of name, but practically no real change of atmosphere or function. The program of automatic supply from the home land had been prepared and adopted by general headquarters in the early autumn of 1917, and had continued to be presented, checked and followed up from there. General Kernan was still required to forward all his communications for the War Department through general headquarters, and they lost their identity as his before they followed the cables under the ocean. This involved a duplicate consideration by his general staff and that at general headquarters, and sometimes weeks of delay and epistolary discussion. From this requirement I was emancipated by General Pershing and permitted to correspond directly with the War Department on supply matters not involving questions of policy.

The effect was immediate and decisive. It enlarged the responsibility I assumed, but at the same time gave me more time to build fires under the boilers of the excellent staff machinery turned over to me by my able predecessor. Under the new order of things the great supply chiefs, Ireland and McCaw, of the Medical Corps; Rice, of the Ordnance; Langfitt, of the Engineers; Rogers and Carson, of the Quartermaster's; Patrick, of the Air Service; Russel, of the Signal Corps; Walker, of the Motor Transport; and Atterbury, of the Transportation Corps; still loyal to the distant commander-in-chief, became at the same time the very efficient staff officers of a nearer commanding general.

THE designation of the staff changed but little in the 10 months from August 1, 1918, but they took on expanded activities and a new personal attitude. There took place the transformation which marked the difference between coördination and command. Matters theretofore coördinated in forwarding for the action of superior authority now received decision from a commanding general on the ground.

Under this organization the supply of the armies was divided into two parts:

1. The procurement, care and storage of supplies, material and equipment; their manufacture, salvage, repair, and cleaning, and the construction, maintenance, and repair of all agencies necessary to accomplish these purposes were vested in the commanding general, Services of Supply. His responsibility for supplies ended on their arrival at the advanced depots, though he exercised administrative command farther to the front.

2. The responsibility for ordering supplies out of intermediate storage and having them transported to advanced storage and the organizations at the front, and for distributing them to the several organizations in advance of the regulating stations, was vested in an agency new to our service, called "regulating officers," who operated directly under G-4 at general headquarters.

The responsibility and accomplishments of the Services of Supply comprised, generally, the procurement, forwarding, storage, care, and salvage of vast quantities of supplies of all kinds; immense projects of construction of roads, docks, railroads, buildings, etc.; the hospitalization necessary for an army of 2,000,000 men; the transportation of men, animals, and supplies by rail, by ships, and by inland waterways; the operation of the largest telegraph business in military history and a complete and efficient telephone system; replacements; reclassification, according to aptitude, of many hundreds of officers and men; the establishment of leave areas and of welfare and entertainment projects; the liquidation of our affairs with France; and the final embarkation of troops for America, popularly known as "getting the boys home." Several years had passed since a ship had crossed the seas to "get the boys out of the trenches by Christmas."

There were two sources of supply—(1) requisition on the United States and (2) purchase in Europe. Not everything that we needed could be furnished from the United States nor was there tonnage to transport it if obtainable. A program for automatic flow of supplies was in force and followed, generally, by the War Department. To obtain supplies from Europe a general purchasing board with a general purchasing agent as chairman was created in August, 1917. This institution combed the neutral countries of Europe for supplies of all kinds, and at the time of the Armistice had procured 10,164,135 ship tons as against 6,215,933 ship tons brought from the United States.

Signal Corps Photo.

U. S. Dock No. 3, Filled with Supplies, St. Nazaire, France, 1918

Its main purpose had been to prevent competitve purchasing and save tonnage. Its activities were extended to include the statistical, control, labor, technical, and accounts bureau as well as membership—the most influential—on the Interallied Board of Military Supply. The man who was the general purchasing agent and dominated these tremendous transactions throughout our participation in the war was Charles G. Dawes, sometime Vice-President of the United States and now ambassador at the Court of St. James. It is hardly possible to overstate the difficulties that beset such a position, and the unrivalled business capacity and magnetic personality which enabled this officer to overcome them so successfully.

IN my initial inspection of the base ports, made with General Pershing when I assumed command, my task was indicated to me as speeding the unloading of ships and the moving of men and supplies from the base ports. The War Department and the commander-in-chief were alike alarmed at the mountains of freight that were piling up on the wharves, and the increasing time taken to unload ships. Fifteen days was the average time between arrival and departure of ships bringing supplies from the homeland. There was a time when 72 days were required for the turnaround completing a round trip.

At Bassens, on the Gironde River near Bordeaux, we had built a 10-berth modern dock fully equipped with gantry cranes. The freight was piled so high on these docks that engineers gravely discussed the possibility that its mass might cause a slip of the entire structure into the channel ooze of the Gironde.

It seemed to me that what would now be called the "public relations" side of the command at Bordeaux had been developed to the atrophy of the freight-handling function. I called this to the attention of General Pershing and recommended to him the principal change in command that I found it necessary to make during my time with the Services of Supply. The problem at Bordeaux seemed to me to call for something more than the ability to get along well with our Allies. It needed the training of an engineer, a willingness to take responsibility when accompanied by authority, and enough youth to furnish drive and domination. I asked the Commander-in-Chief to send me William D. Connor, then commanding a brigade of the Thirty-Second Division fighting on what Secretary Baker called the "farthest frontier of freedom." Having myself within the week said farewell to the front, I could easily understand the feeling with which General Connor received orders for Bordeaux. I doubt if the lapse of 12 years has brought me his entire forgiveness; but I point out that a great opportunity was afforded him in a notably difficult task, which was so welll done that it led to his succession as chief of staff of the Services of Supply two days after the Armistice, with the eventual command and liquidation of the entire enterprise. There were many brilliant brigade commanders in the American Expeditionary Forces, but only one officer conspicuously successful in the variety of difficult tasks that fell to him.

The visit to Bordeaux and other ports convinced me that the congestion was in large part due to an improper division of responsibility and authority between the base section commander and the representatives of the transportation corps, which was charged with the unloading of ships and dispatch of cargoes to destination. The section commander had the responsibility and authority for the labor and stevedore troops when not actually working at the docks; the transport officer had entire authority and responsibility when they were so employed. The section commander shorn of any opportunity for credit or responsibility for blame in the matter of unloading and forwarding freight inevitably concentrated himself on matters for which he was held responsible. The discipline of the stevedores while off duty, their health, and surroundings were to him merely incidents to their use by an entirely independent authority during certain hours of the 24. The transport officer, when the men marched off the dock, officially knew nothing of the conditions that would surround them until he next saw them, or the numbers and condition in which he might expect them to report the following day.

This situation was not the fault of General Atterbury, who had been allowed to come to the American Expeditionary Force with the promise of a "free hand" in the important position of Director General of Transportation. He undoubtedly shared the feeling against the supposed arbitrary martinet of the regular service, and desired independence of such control. It is true that he was honest in his belief that there was danger of meddling with the technical details of his department, and that for reasons unnecessary to discuss, he had found concurrence in that view from certain former officers of the regular service. My conviction, shared by General Pershing after we visited the base ports, was that the transport officer belonged as a member of the staff of the base section commander, and

that only in that relationship could we expect a unification of effort in which both would join, and in the success of which they would have a mutual interest.

Some friction and estrangement had taken place between the commanding general, Services of Supply, and the Director General of Transportation in adjusting their relations with each other. This had led to the appointment of a board to consider relationships between the transportation corps and the remainder of the services, which was really what in civil life would be called an attempt at arbitration. This complicated the difficulties in my attempt to settle the relationships at the base ports in a military way. My stock illustration, during the many hours spent in convincing the transportation corps that to put the transport officer on the staff of the section commander would not bring technical intereference, was that the surgeon is a staff officer of the commander, but no case was of record where the commander had mixed in on the amputation of a leg, or other technical duty of the surgeon. The fullest opportunity was given for discussion not only to the head of the transportation corps, but to his principal subordinates. General Orders, No. 40, S. O. S., 1918, placing the transport officer on the staff of the base section commander, settled the matter as it should have been settled, in which view I believe the able Director General of Transportation and his fine corps concur without reservation.

THE inspection journeys of the commanding general of the S. O. S. could not be well performed in a motor car, considering the distance from Tours to even the nearest base port, the limitation to daylight travel, and the impossibility of being accompanied by more than a single staff officer. Previous experience of mine in the Philippines, while in command of a constabulary district, had convinced me that the performance of officers and men in remote and distant posts was almost directly in proportion to the frequency of visits from their district commander. It furnishes the opportunity not only to see how badly things are done but how well they are done, and the effect on the visited organizations is immediate and certain. There were so many conditions at the base ports that required the giving of orders on the ground, and the personal attention of responsible staff officers of the commanding general that some method of inspection that brought them there together was necessary.

I asked General Atterbury to sound out the French on the use of a special train for my purposes, and if they were agreeable to giving it schedules at our convenience, to assemble such a train. He did so, and the results justified not only the request but his experienced judgment in making up the train. It was made available in my second week in the S. O. S. and continued in use until just before my relief in May, 1919. It consisted of a director car, for myself and half a dozen staff officers; of 2 wagon-lits cars for extra officers and necessary enlisted personnel; of a restaurant car half provided with small tables, and the other half constituting a dining room with a large table seating 10 people; 2 box cars fitted up with telegraph instrument and a telephone exchange, the latter connected through the train to the several coaches; a flat car carrying 2 motor cars at the rear of the train, with ramp for unloading and loading at any place where we chose to stop.

This made us independent of the train movements, and obviated borrowing motor transport at places visited. The colored labor and stevedore regiments furnished the train an ample number of veteran Pullman employees of all kinds. In the first hundred days of my command at Tours I spent 55 nights on this train.

For inspection trips the train was filled to capacity by invitation to the heads of staff services, particularly the Chief Quartermaster, the Chief Surgeon, Chief Engineer and the head of the engineer construction service, the Chief of Motor Transport, and the Director General of Transportation. Any of these chiefs might at discretion substitute a staff officer empowered to give orders in his name. I took with me my personal staff, including the interpreter and a stenographer and orderly. We invariably traveled at night and did business in the daytime. The French at any principal station permitted the telegraph service of our train to cut in on their wires, and the telephone exchange to connect with the local and long-distance telephone circuits. On arrival at destination the motor cars were at once unloaded, a designated aide took charge of the train, called my office at Tours by telephone, and ascertained what matters, if any, required action; the other aide and stenographer and accompanying staff officers went with me for inspection of all our activities at the place. Generally, we brought the local commander to the restaurant car for luncheon and dinner instead of constituting ourselves a burden on his ménage.

Signal Corps Photo.

American Freighters in St. Nazaire Harbor, France, April, 1918.

Such matters as called for orders were attended to, the necessary telegrams dictated on the spot, and sent on return to the train. It was possible to telephone to any point in France and England, and in later days I talked from that train in southern France to the commander-in-chief visiting the army of occupation on the Rhine. Only those who have attempted to telephone in France or England, using the local systems, either in peace or war, can appreciate the smooth efficiency of the network of communications which General Russel with his Signal Corps had provided for us before the Armistice. Sixty expert telephone girls, selected from New England communities and speaking the French of old Quebec, operated the great telephone exchange at Tours. Much of the business of the Services of Supply was handled by our telephone and telegraph services.

IN August, 1918, there was unloaded 525,291 tons of freight; in September, 563,147; in October, 636,225; and in the first 11 days of November, 229,135 tons. I recall being at Brest one day that autumn and from the hill above the old city where my train was sidetracked, seeing 14 transports enter the harbor with 46,000 men on board. That afternoon there were lightered ashore some 36,000 of them, while coincidently 18,000 men marched down to Brest from the great camp of Pontanezan and took trains in the direction of the front. We men of an older day can remember that in 1898 we took six weeks to get 35,000 men to Cuba across summer seas uninfested by submarines or surface craft, and thought it a great military accomplishment.

The home-loving American negro of the stevedore and labor units suffered a great deal from the inclement whether of western France. He has apparently a peculiar liability to pulmonary troubles. His was not an inspiring task. There were many such stevedores who had never seen salt water until they embarked for France and their cotton-field habits were no particular training for unloading ships. They were quite generally homesick and their morale was not high. Yet they were the ones who must take the first steps in quickening the turn around of Army transports. Some form of competition had to be devised to stimulate their activity. The problem was one of grading the work done in each port to form a basis of comparison. Was it fair to figure the tonnage of one locomotive shipped intact to France and hoisted to the waiting rails beside the ship against the same tonnage of flour taken laboriously from the hold of some other ship in a port with entirely different facilities for unloading? Could coal which was hurled down chutes be compared with ammunition? In the end we hit upon the idea that competition between ports must be a comparison of competitions held within the ports themselves. Each port would compete with its own previous record of achievement in tonnage and the percentages of gain would be compared with those of each other base port.

The statistical division at Tours thus figured the handicaps of the various ports. Each base commander appointed a suitable officer to head the activities in his port. We called it "The Race to Berlin" and within a few days it was going at speed. We commercialized homesickness and the winning company of stevedores was promised the privilege of embarking for Hoboken first after the ending of the war.

In addition, we extended an offer of leave and a trip to the balmy Mediterranean area, where a certain number of the winning company in each port went as soon as the race was ended. For the base commanders we offered the pleasure of flying from their flag pole the winning pennant for a month if their men won it.

The race met with instant acceptance. At the hour of starting, which was midnight on an appointed day, the stevedore companies were escorted to their respective places with a blare of bands. Musicians who had considered life fairly easy with a concert or two a week suddenly found themselves blowing ragtime through the days and nights at the head of processions of fresh or exhausted workers. Freight was handled on the docks to the tempo of jazz music. Intercompany competition and intersquad competition became intense, and each week the figures were wired to every port and announced from bulletin boards and from every moving-picture screen in the Services of Supply. The morale of the workers took a sharp turn upward and with it the tonnage figures. On the wall of my office a great chart told the daily story, and an inch of red on the end of a column meant additional thousands of tons started on the railroads of France toward the front.

The arrival of the Armistice cut short the effort and the Race to Berlin was terminated before the appointed day. The rewards were given, however, and a company of happy stevedores soon sailed for home. During the period of the race the tonnage moved through the base ports increased by approximately 20 per cent. This was done on top of what was believed to be full speed efficiency, and an increase of 20 per cent meant thousands of additional tons.

The credit of devising The Race to Berlin, which excited a competitive spirit hard to realize at this distance, was due to Captain Robinson of my personal staff and Mr. Charles M. Steele of the Y. M. C. A., both now business men in New York.

THE exigencies of the situation and the new conditions under which we waged war made necessary the following new services and departments:

Transportation Corps, Rents, Requisition and Claims Service, Army Transport Service, Air Service, Motor Transport Corps, Chemical Warfare Service, Army Service Corps.

Some of these had previous existence in other corps. The following new activities were created during hostilities:

Veterinary Service, Salvage Service, Baggage Service, Remount Service, Graves Registration Service, Reclassification System for officers and men.

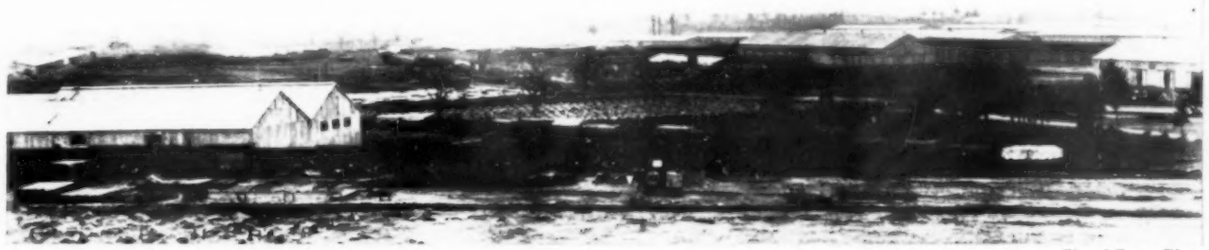
Of the foregoing, perhaps the Reclassification System for officers and men merits more description than is furnished by the title. This not only involved the physical reclassification of officers and men only partly fit for active duty, but the reclassification of officers according to fitness for special duties.

A number of officers were found unfit for combat duty, and many in noncombatant positions were found unsuited to the duty on which employed. A scientific effort was made to reclassify these officers. A total of 1,101 officers was reclassified, of which 270 were sent before an efficiency board for elimination. Nine hundred and sixty-two wounded or otherwise disabled officers were reclassified, their services being used to release officers on duty in the S. O. S. and able to do combat duty.

Individual officers proceeding to France were given a confidential order by the War Department, directing them to report to the commander-in-chief. To an officer without previous military experience this was taken literally, and on coming ashore his impulse was to seek the commanding presence, sometimes being willing to proceed via Paris to reach it. It was necessary, in January, 1918, to create a casual officers' depot into which these arrivals might be directed, and later requisitioned out as was other commodity in storage. The depot was located at Blois, and to it casual arrivals were automatically evacuated from the ports. In March, 1918, there began to arrive at this depot, officers found unsuited for combat duty, and those to be discharged for inefficiency. The reclassification system was an evolution resulting from the needs of the time. "Reclassification" and "reassignment" were first mentioned in orders from general headquarters of July 16, 1918, which

granted authority to corps commanders to order to Blois officers who were found unfit for duty with combat divisions. This authority was later extended to army and division commanders.

Besides those from combat units and casuals from the United States, replacements for the various S. O. S. services were sent there for classification and assignment, and all officers and enlisted men evacuated from hospitals were automatically sent to the depot for similar treatment. All available data regarding the individual was considered no matter from what source he came. These papers were sent to S. O. S. headquarters at Tours and the officer was ordered there for personal interview and reclassification, which resulted either in his return to Blois for action of an efficieney board, or his assignment to such duty as his vocational experience or special qualifications suggested, or ordered to a replacement depot for return to combat duty in another division. This delicate and important duty was well handled by Col. John P. McAdams, deputy chief of staff, one of the best staff officers developed by the S. O. S., and his assistants. Cases of general officers, of whom there were at one time 11 at Blois, were handled by myself. It is interesting to observe that of officers serving in the American Expeditionary Forces, 1 regular in every 40, and 1 temporary officer in every 80 were found unfitted for the duties they were performing and had to be reclassified. One regular in 125 and 1 temporary officer in 335 were ordered before efficieney boards. Approximately 23 per cent of the regular officers and 11 per cent of the temporary officers found unsuited for duty with troops were returned to such duty after reclassification. Of these less than 5 per cent were again found wanting. The difference in standards required must account for the proportionately larger number of regulars to be relieved from duty as unfit.



Signal Corps Photo.

Section of Storage Yards and Warehouses, Gievres, France, 1918.

WITH the signing of the Armistice the passenger machinery of the S. O. S. went into reverse, and the tide of military humanity turned toward home. To enable him to return to his important duties in the United States, General Atterbury was presently relieved as Director General of Transportation by Brig. Gen. Frank R. McCoy, who had joined him as assistant just after the Armistice, and thus returned to staff duty after distinguished service as a regimental and brigade commander at the front. Every railroad in France was congested by her own urgent needs and much of our troop movement was across her own streams of traffic. The liaison with their railroad administration was one of extreme delicacy, and the whole situation was handled with consummate skill. The return of American troops to the United States received less attention than the movement in the other direction, but, less the submarine menace, presented the same difficulties, with a slight political flavor.

Manifestly the human tide could not be permitted uncontrolled to flow into ports already congested and there await the home-going transports. Angers became a depot for forwarding individual officers. Le Mans, which had been a replacement depot, became a vast forwarding camp for returning divisions. Here they were outfitted for the westward journey, their accounts settled, and examinations made. From here they were sent to Brest and St. Nazaire when ships were ready for them. A permanent camp staff administered and supplied them, and their division commander and his staff had no responsibility for them. For practical purposes the camp operated as a great military hotel. Similar machinery functioned at Bordeaux, St. Nazaire, and Brest. In the great camp at Pontanezan at Brest these activities were brought to their highest perfection under Gen. Smedley D. Butler, of the Marine Corps. Mass delousing, mass bathing, and mass feeding were the order of the hour. A unit of 6,000 men were one morning furnished 24,000 hot cakes with their breakfast, and it was all in the day's work.

No man went home without physical examination, and no man was allowed to proceed if he was unfortunate enough to have venereal disease. What America owes to this fact and the previous treatment of this problem can never be calculated. The fact itself passes unnoticed among the comments on the results of the war, but also among the numerous sins charged to its influence. An alarming number had those unhappy diseases when they entered the service; none had them when he left.

When the Armistice was signed supplies and personnel were in full flow toward Europe and vessels carrying them continued to arrive for several months afterwards. The war ended with millions of tons of supplies of all kinds at the ports, in storage, in transit, and in the hands of troops. To have returned these to the United States would have necessitated the retention of hundreds of thousands of American soldiers in France for an indefinite period to have handled them. The railroads of France, busy with their own problems of demobilization and of rehabilitation, could not have carried them. The same amount of tonnage would have been required to get them across the ocean as had

brought them over, and the home markets would have been demoralized for years to come. To have attempted to sell them in France except to the government would very properly have involved the payments of customs duties on all of them to protect the French markets.

During the war, claims of the French Government, its railroads and people, covering—and properly covering—almost every class of service, rental and damage, had been accumulating against us. Their settlement by us would have required the work of many years, utterly hopeless of a conclusion satisfactory to either party.

One of the outstanding accomplishments terminating our military sojourn in France was the work of the liquidation commission, composed of the late Edwin B. Parker as chairman, with Senator Henry Hollis, of New Hampshire, Hon. Homer H. Johnson, of Cleveland, and General Dawes as members. It concluded the sale to France of all our surplus supplies of every kind in that country, and an arrangement by which the French Government assumed the settlement of all claims rising out of our stay in France. It was a splendid piece of work.

One service rendered by the French could never really be remunerated. That was the inestimable liaison from which every branch of our Services of Supply, and all our major combat units benefited. From the great Mission Militaire at Chaumont, headed by the soldierly General Rageneau, down to humblest sous-lieutenants in some obscure staff office at Tours, the war could hardly have been carried on without them. Every staff service of theirs was represented by the French officer in the corresponding American service or department. Their usefulness can hardly be overstated. General Michel is supposed to have said that the two great discoveries of the war were liaison and profondeur.

TIME heals wounds and distance lends enchantment. Whether or not the commanding general of the Services of Supply was reporting to the wrong authority at general headquarters; whether he was actuating the official machinery himself or responding to strings pulled by some strong, silent man near him; the relative value of the dollar-a-year man compared to the professional soldier; the injustices of arbitrary commanders; the hasty relief of officers from combat units that was sometimes the frantic and unsuccessful effort of incompetent leaders to save themselves; the tragedies of Blois than which there are to some no more melancholy memories in all our military history; the heartburnings of a service that worked so hard and so fruitfully for others that it, itself, was never equipped in either men or munitions, and never able to straighten out in its stride; these are no longer of importance except to a few individuals with long memories. Time has, in some instances, remedied my own conspicuous inability to obtain at the time the promotion which was due men who served under me. So far as I know, but one officer was promoted to brigadier general while serving under me in the Services of Supply. Men outstanding in efficiency like Bash, McAdams, Sewell, Smither, Symmonds, Hull and Cavanaugh, every one of whom by merit and the tables of organization in force at the time, should have worn stars, went through to the end unrewarded. Perhaps, the best we can do is to repeat for the ten-millionth time, *"C'est la Guerre."*

To this day the military student searches in vain for any coherent record of the machinery of supply used in our Civil War. The records of the Service of Supply in France were carefully and even meticulously kept.

I CAN do no better in terminating this address, already much prolonged, than to paraphrase the closing words of the final report of the commanding general of the Services of Supply. You have heard the inadequate account of one part of the world's greatest military adventure, in which a nation, engaged in war, across seas, 3,000 miles from its own shores, transported its soldiers by the millions; its material resources in millions of tons; and counted the cost in billions of dollars as well spent in a great cause. It is the impersonal record of the greatest military-industrial enterprise the world has ever seen. No country was ever more efficiently served by its sons than was ours in its Services of Supply. No general ever owed a greater debt for personal loyalty than is mine for the splendid support and teamwork enjoyed while in command of that service. Yet, who can measure correctly the relative excellence and justly weigh the rewards for services that covered almost every field of activity from the highest type of staff work to the humble toil of the dock stevedore, each essential to the success of the whole? Every trade and profession known to our civilization contributed its members to this enterprise. Officers who had spent their lives preparing for the command of soldiers in battle, cheerfully threw over the ambitions of years and forgot the bitterness of disappointment in their enthusiasm for this service; black men from the cotton fields of our South toiled on docks and in warehouses, and built roads that no soldier might go unfed; lumbermen operated in the forests of the Vosges and Pyrenees; millionaires contributed their great business experience and captained new industries; lawyers of eminence protected the interests of the country; chiefs of the great railroad organizations of America brought their unexcelled men and methods to the success of the transportation service; tremendous engineering problems were solved by leaders in that profession; the distant markets of other countries were searched by trained buyers to save precious tonnage; men labored under earth and water, and met dangers in the air and under the seas; officers and soldiers from the battle fronts restored only to partial health contributed their shattered strength and maimed bodies to this work; the best medical and surgical skill of the world organized and administered hospitals in numbers and size never before seen; salvage services were organized on an immense scale; the great welfare organizations ministered to the morale and entertainment of the supply army; leaders in the world of electricity covered France with a network of uninterrupted communications; kings of finance, diplomats, linguists, artists, artisans of all arts, experts and organizers of all phases of industrial life, caught the step and marched with the Services of Supply. Without the excitement and glamor of combat service, often unobserved, sometimes unrecognized and seldom adequately rewarded, these men quietly and unselfishly contributed their part to the winning of the war.

In such numbers and in such efficiency were these men deserving of their country that individuals can not here be singled out by name. They worked as a great team which was only striking its stride as the war ended. Time will lend its perspective and history will write the story of their achievements as unsurpassed in military legend.

A New Weapon for Field Artillery

A Forecast of Division Armament in the Next War

By G. M. Barnes*

DEVELOPMENTS during and since the war are tending to render the existing field artillery matériel obsolete. It is a well known fact that new field guns and carriages of the division, corps and army types have been built since the war which are greatly superior to the war types in that the guns give greater ranges. However, the matter is more serious than that, since none of the war types and few of the post-war types of artillery will meet the new demands which will be required of them in future wars.

High-speed targets in various forms are gradually entering the field of fire of all types of field guns, such as the new high-speed trucks used as prime movers for artillery and for carrying infantry and tanks having cross-country mobility and speeds heretofore unthought of. But even more menacing than the high-speed tanks and trucks are the many types of aircraft, carrying bombs and machine guns, which may swoop down upon the infantry or artillery without warning.

It is well known to all field artillery officers and other officers and civilians as well, who have given thought to the problem, that the present types of field artillery, as exemplified, for instance, by the famous French 75-mm. gun, are wholly incapable of dealing with these high-speed targets. Few of the carriages for these guns permit sufficient elevation for firing at aerial targets, or have sufficient speed in traversing or elevating.

Unfortunately, not only the guns and the carriages but the fire-control instruments, which have been developed for use of field artillery, are wholly unsuitable for use against high-speed moving targets. The fire-control instruments used by a field artillery battery have been developed on the principle of keeping this equipment as light and as simple as possible. Practically all firing data must be computed slowly and laboriously by the personnel of the battery. It will be at once evident that such methods are found lacking when attempting to fire guns continuously at moving targets.

With luck a battery of divisional guns might destroy a high speed tank, but there could be no assurance of the same result using the present types of field carriages and fire control. It would be absolutely impossible to bring effective fire upon an airplane traveling at a speed of 100 miles per hour or more, and to attempt it—purely a waste of ammunition. The present methods of fire control are being adhered to although the increased ranges of the post-war guns necessitate refinements in fire-control instruments and methods.

Furthermore, practically all existing field artillery carriages, up to this time, are defective from the standpoint of modern high-speed transportation in that they cannot be hauled at speeds greater than about 15 miles per hour without seriously damaging the gun carriages and their mechanisms. All the artillery of the World War period was limited in this respect since it had been designed with the idea of using horses or the slow-speed tractors available at that time for tractive forces. Since the war, trucks have been built which are capable of hauling gun carriages at high speed. Commercial development makes it imperative that gun carriages of the future be so constructed that these high speeds can be taken advantage of, not only on good roads, but when the gun carriages are trailed across country.

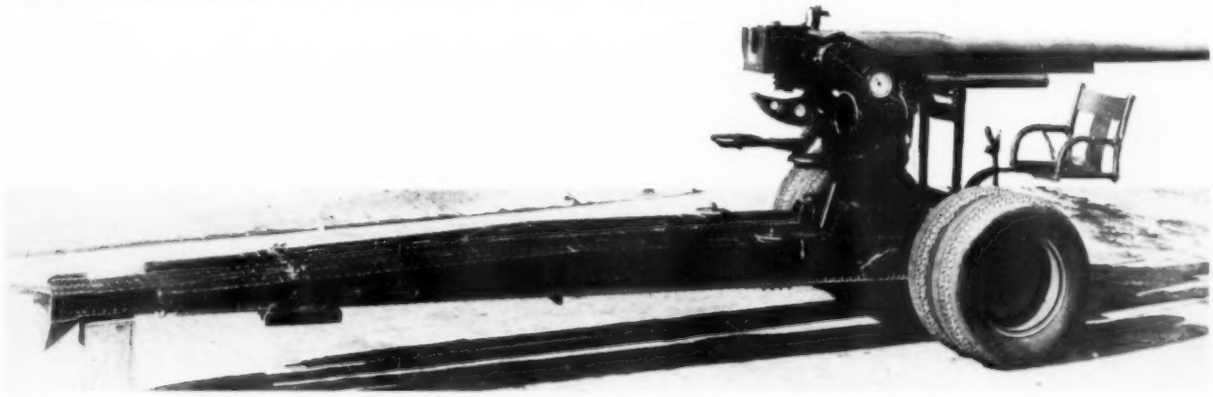


Fig. 1. The New, All-Purpose 75-mm. Gun Carriage in Traveling Position.

These new conditions, thus briefly outlined, call for field artillery of a new type. The present ideas concerning fire control must be revised and the fire-control equipment of the battery must be augmented so that these batteries can bring effective fire against stationary ground targets, and can also be used effectively both against rapidly moving ground targets and, with equal accuracy and facility, against high speed targets in the air.

A NEW type of field gun carriage (Fig. 1), which has been developed with the idea of meeting the new requirements referred to above, was completed recently at Watertown Arsenal. This carriage mounts the high velocity 75-mm. field gun (muzzle velocity 2,175 ft. seconds) which

*Chief, Design Section, Watertown Arsenal, Watertown, Mass. Major, Ordnance Department, U. S. Army.

gives a maximum range of 15,000 yards with a 15-lb. projectile.

In order that the requirements of high speed transportation may be met, the new carriage has been equipped with wheels mounting balloon tires and having roller bearings at the hubs. The design is such that either single or dual tires can be mounted. The newly developed puncture-proof inner tubes are used. While the dual wheels and tires increase the weight of the gun carriage about 400 lbs., it is believed that tests will show the advantages of having the additional tire contact area. Furthermore, the two additional wheels and tires may be considered as spares in which case, if one of the tires were punctured, the vehicle would not have to stop. The increased ground contact area will make it possible for the vehicle to pass through sand and soft mud. The construction is such that the gun carriage proper is carried on the wheels and axle as a spring load.

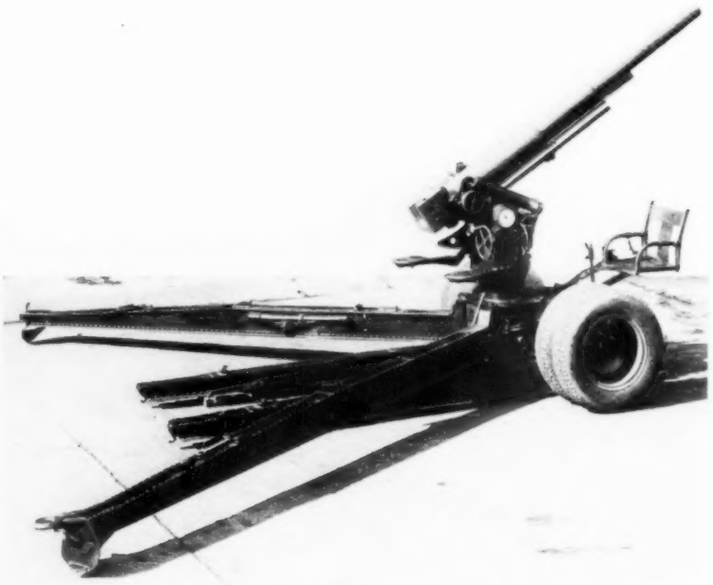


Fig. 2. The 75-mm. All-Purpose Gun Carriage in Firing Position. Traverse 90°; Elevation 45°.

The gun can be fired by opening out the rear trails and supporting the front part of the carriage by means of the two spare trails as indicated in Fig. 2. Two outriggers with built-in screw jacks are placed on the ground under the carriage pedestal. When in place, the screw jacks are tightened against the bottom of the carriage, thus the vertical component of the firing load enters the ground through these two outriggers which serve to protect the balloon tires, roller bearings and the spring suspension from the firing load. The gun can be fired in this manner through an angle of traverse of 90 degrees and at elevations from 0 degrees to plus 80 degrees.

If all-around fire is desired, the carriage can be put in a second firing position. In this case, the two outriggers are used as levers for raising and lowering the carriage. The wheel and axle assembly can be removed quickly from the pedestal of the gun carriage and the latter lowered to the ground. The two spare outriggers are then put into place to complete the base for the carriage. In this position (Fig. 3) the gun can be fired through 360 degrees of traverse and at angles of elevation from 0 degrees to plus 80 degrees. The top carriage can be cross-levelled plus or minus 6 degrees or a total of 12 degrees. Spirit levels are attached to the top carriage to be used when cross-leveling the gun trunnions. Thus the trunnions can be made level before firing either from the first or second position. Cross-leveling of the carriage is a necessity, if the gun is to be fired by the indirect method at moving targets. Furthermore, it insures more accurate fire, when firing by Case I methods.

In arsenal trials, using untrained men, the carriage was put in the first firing position (for 90 degrees traverse) from the traveling position in one minute (Fig. 4), and in the second firing position (Fig. 5) (for 360 degrees traverse) from the traveling position in four minutes.

It is believed that such a gun carriage fully meets the requirements which were outlined at the beginning of this article. The weight of the gun and carriage in the firing position is 5,800 lbs., or nearly twice that of the low-velocity 75-mm. gun carriage of the World War type. However, assuming a 4-inch penetration of the tires into the ground, the area of the tires in contact with the ground is 832 square inches as compared with 194.6 square inches for the French 75-mm. field gun, M 1897, equipped with steel tires, and the ground pressure is 6.9 lbs. per square inch as compared with 13.7 lbs. per square inch for the French 75-mm. Thus it will be seen that the new carriage will undoubtedly possess greater cross-country mobility than the lighter carriage. This low weight for a high velocity, all-around-fire carriage with cross-leveling features, dual balloon tires, brakes and spring suspension, is made possible by taking advantage of steels of high physical qualities, of the new welding process which has been developed at Watertown Arsenal, and by making parts of the carriage, where possible, of strong aluminum alloys having one-third the weight of steel. This carriage is equipped with the antiaircraft type of elevating and traversing mechanisms, employing roller bearings throughout. All backlash is eliminated making it possible to lay the gun with an accuracy of 1/2 mil on either elevation or azimuth.

Fire-Control for Artillery of the New Type. The new gun carriage which has been described is being fitted with fire-control equipment in order that the above ideas may be tested. When more complicated fire-control instruments are mentioned for field artillery, the questions of cost and weight are always raised. Both of these become factors of little importance if an increase in the percentage of hits can be realized by adding additional fire-control instruments to the battery. For example, let us assume that the fire-control instruments of the type to be described cost $20,000 per battery. This represents the cost of 800 rounds of 75-mm. ammunition at $25 per round. If a battery fires 200 rounds per gun using inaccurate data, it has wasted the price of proper fire control.

The Antiaircraft Service has already found that by changing to the new type of fire control and using indirect

Fig. 3. The 75-mm. All-Purpose Gun Carriage in Position for 360° Traverse, 80° Elevation.

methods the percentage of hits on aerial targets can be more than doubled for shorter ranges and the increases at the longer ranges have been even greater. If the accuracy of fire of field artillery against moving targets can be improved by new fire-control methods, the instruments can be quickly paid for by the savings in ammunition. The same line of reasoning may be followed as to weight. Assume the weight of a complete set of battery fire-control instruments of the new type of 1,500 lbs. This represents the equivalent of about 75 rounds of 75-mm. ammunition. If ammunition can be saved by increasing the accuracy of fire, then it is better to transport fire-control instruments than ammunition. In other words, the slogan in peace or war should be "Buy fire control to save ammunition."

The fire-control equipment which is being furnished for the new type of gun carriage will, for the purpose of this discussion, be divided into those instruments which are carried on each gun carriage, which will be designated as "On-carriage fire-control instruments," and the remaining instruments required for the battery will be designated as "Off-carriage fire-control instruments."

ON-CARRIAGE FIRE CONTROL. A panoramic sight and elevation quadrant have been provided for the gun and carriage so that the present field artillery fire-control methods can be used. The mountings for both the panoramic sight and quadrant have, however, been simplified since the gun trunnions can be cross-levelled before firing starts. Therefore, the standard mounting for the panoramic sight can be simplified since the mechanism required for correcting the "out of level" condition of the gun trunnions can be eliminated. The cross-levelling features usually required for the elevating quadrant also can be dispensed with.

In order that the Case III indirect method of fire control may be used with battery, two additional instruments are required on each gun carriage (Fig. 6). These instruments are an azimuth receiver geared to the traversing mechanism and an elevation receiver, which is geared to the elevating

Fig. 4. The 75-mm. All-Purpose Gun Carriage in Position for 90° Traverse, 15° Elevation.

Drawing by A. A. Cambria, Watertown Arsenal.

Artist's Visualization of a Battery of the New All-Purpose Gun Mounts Using Latest Fire-Control Equipment to Repel Air and Land Attack.

mechanism of the gun carriage. They should be located so that the azimuth and elevation gunners can watch the dials conveniently when maneuvering the elevating and traversing handwheels. Each receiver has two sets of pointers. One set is driven from the central station director electrically and keeps step with the data computed by the director continuously and without loss of time. The other set of pointers is geared, e. g., to the elevating mechanism of the gun carriage. Thus by matching pointers the gunner can keep the gun set in elevation in accordance with the readings continuously being sent from the central-station instrument. By using these receivers, telephones to the gun can be dispensed with, as the former can be used to transmit to the gun, if desired, not only Case III firing data but also deflections and ranges. These receivers are relatively light and compact as will be seen from the illustration (Fig. 6), which shows the direct current type of data transmission system.

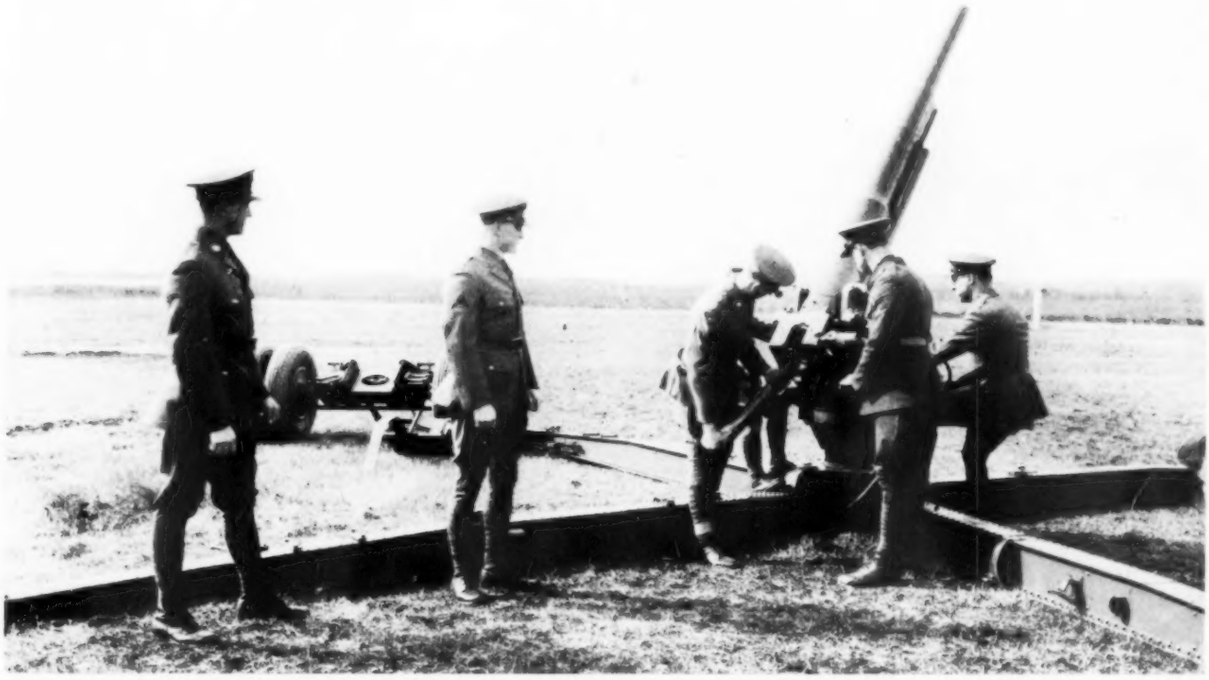


Fig. 5. The 75-mm. All-Purpose Gun Carriage in Position for 360° Traverse, 60° Elevation.

When the data transmission system was first introduced to the Antiaircraft Service, officers were skeptical as to whether this equipment would be sufficiently rugged for field service. Tests have shown that the electrical data transmission system is more reliable than the field telephone sets which were formerly used to transmit the firing data to the guns.

OFF-CARRIAGE FIRE CONTROL. In addition to the present battery fire-control instruments there should be a mechanical computer for solving map problems. An instrument of this type will be issued shortly by the Ordnance Department to the Field Artillery Board for test. In the German Army every battery is now equipped with such a mechanical computer which is carried as part of the battery equipment. It furnishes corrected ranges, angles of site and deflections, and automatically corrects for the velocity and direction of the wind, muzzle velocity, density of atmosphere at different altitudes and heights, and battery and target. By changing one platen which has several cam-slots cut in it, the machine can be used for different weights of projectiles and guns of different calibers. The instrument is universal in character and can be issued to any battery: it is necessary only to provide the proper platens. The machine, in solving field artillery map problems, will reproduce a range table with an accuracy of plus or minus 10 yards. It is so arranged that the individual guns of a battery can be calibrated and the muzzle velocity correction for each gun set off on the instrument. The corrected data for each gun are automatically given when the muzzle velocity correction lever is changed for the setting of that gun. The calculator also furnishes data referring to the actual position of each gun of the battery, the position of which is indicated on the map. The device is small, about 40 inches long, and compact. It eliminates all computation in the solution of map problems. Furthermore, soldiers can be taught to operate it in a few hours.

The battery fire-control equipment required for dealing with high-speed moving vehicles and airplanes would consist of a range and height finder of three or four meters base and another central station computing machine (hereafter called a director), together with an electrical data transmission system for hooking in with the elevating, azimuth and fuze receivers on the gun carriage. This equipment would be similar to that now used by the Antiaircraft Service and is described in the following paragraphs.

RANGE AND HEIGHT FINDER. The range and height finder is used for measuring the ranges of visible ground targets and the altitudes of aerial targets. Tests with instruments of this type conducted by the antiaircraft artillery have shown that the stereoscopic type of instrument is superior to the coincident type. The stereoscopic type of range and height finder is a very valuable instrument for artillery since the operator very accurately can sense "overs and shorts" when the bursts can be seen. For antiaircraft fire the instrument is the only method of making corrections based on observation unless a flank observer connected to the battery by telephone can be used. The one-meter base range finder assigned to the field artillery does not possess sufficient accuracy for long-range firing, and, of course, could not be used for measuring the altitude of an airplane. The accuracy of all types of monostatic range and height finders varies directly with the length of base. Thus, a four-meter range and height finder would have four times the accuracy of a one-meter instrument.

Fig. 6. The New All-Purpose Gun Mount (left-side) Showing Azimuth Receiver, Traversing Mechanism and Mounting for Panoramic Sight.

CENTRAL STATION DIRECTOR. The director is the instrument which computes automatically the firing data required for firing at rapidly moving targets. The antiaircraft director automatically and continuously computes the ground speed of the target, angle of approach and finds the unknown future range and time of flight corresponding to the future position of the target. In addition, it adds algebraically corrections for drift, muzzle velocity, direction and velocity of the wind. The input of the instrument is the altitude, the present azimuth and angular height of the target. The output of the instrument is the azimuth, quadrant elevation and fuze setting corresponding to the future position of the target. Transmitters are attached to the three output shafts of the director so that these values can be continuously sent to the elevation and azimuth receivers on the gun carriages and to the receivers on the fuze setters.

The Vickers type of antiaircraft director, with modifications, would be a suitable instrument for use of the field artillery. A 30-volt storage battery would be required for supplying the current for the electrical data transmission system. During the war the firing data for antiaircraft artillery was telephoned to the guns. This introduced a dead time of 8 to 10 seconds into the firing data and made it impossible for the battery to secure a large percentage of hits upon aerial targets. The elimination of this dead time has contributed greatly to the success of the post-war antiaircraft matériel.

While the director was designed solely as an antiaircraft fire-control instrument, it could be modified and used to compute Case III firing data for a rapidly moving ground target, such as a tank, taking range measured by the range and height finder as an argument instead of altitude. If a field artillery director of this type were developed, any problem involving visible targets on the ground or in the air could be solved. One of the great advantages which should not be overlooked is the fact that men can be trained in a few days to use successfully these automatic instruments which, while very complicated internally, are very simple to operate.

One additional instrument would be required to complete the fire-control equipment of our battery: a fuze-setting machine. A fuze setter required for this type of fire control must be equipped with a receiver similar to those placed on the gun carriage. The receiver is geared to the fuze setter so that the operators of the latter continuously can keep in step with the fuze readings being transmitted electrically from the director. Such a fuze setter, known as a Continuous Fuze Setter, M1, already has been developed for the Antiaircraft Service. One of these fuze setters has been tested by the Field Artillery Board. Such an instrument has little advantage over the bracket fuze setter unless it is to be used in connection with the indirect method of fire control in which electrical data transmission devices are included. In the case of the latest type of the antiaircraft carriage (3-inch antiaircraft mount, M2) the fuze setter is mounted on the carriage. Because of lack of room,

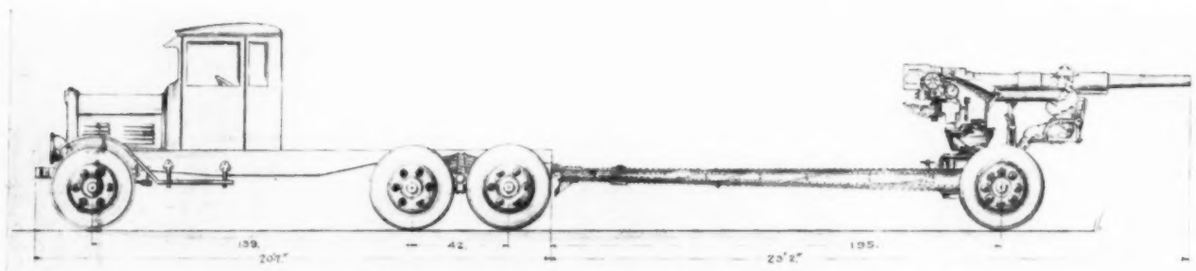


Fig. 7. Six-Wheel, 3½-Ton Chassis With the New All-Purpose 75-mm. Gun.

in the case of the 75-mm. universal field gun carriage, brackets are provided on all four outriggers so that the fuze setter can be attached to the outrigger most convenient to the breech. The fuze setter should be as near the breech as possible so that the shell can be fired as soon as possible after it has been removed from the setter. In the Antiaircraft Service, the time required to remove the fuze from the setter, insert the round in the gun, and fire, is one second. This second is allowed for and set into the director. The rate of fire of the 3-inch antiaircraft mount, M2, averages 25 rounds per minute. The rate of fire of the new 75-mm. gun on the universal type of carriage illustrated above should be greater as the ammunition is lighter.

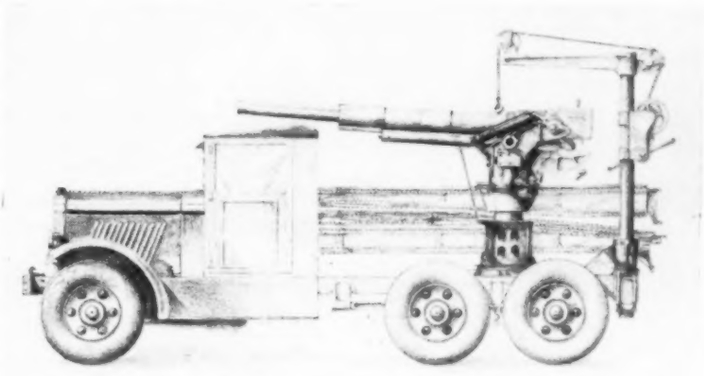


Fig. 8. The All-Purpose Mount for 75-mm. Gun on $3\frac{1}{2}$-Ton, 6-Wheel Truck.

PRIME MOVERS FOR DIVISION ARTILLERY. Many officers think of automotive vehicles in terms of the type of trucks and tractors which were used in France in 1918. This is not strange since few modern military automotive vehicles have since reached the service.

The great strides which are being made in commercial motor vehicles are everywhere apparent. Fleets of high speed trucks and busses daily run between cities separated by great distances. Such vehicles carry many tons of pay load and, with their modern powerful engines, hydraulic brakes and balloon tires, can travel at speeds which make it difficult for the light weight so-called pleasure automobile to duplicate. In short, all around us we see a new order of things and realize that at least the greater part of the artillery must be motorized if we are to be present with our artillery in future battles.

Strangely enough this country, which is the leader far in advance of all other countries in automotive development, trails in the motorization of artillery. The Italians have almost completely motorized their artillery with the famous Pavesi wheel tractor. In France where gasoline is a strategic material, great efforts are being made to build artillery prime movers which can use a gas generated from wood on the vehicle, while the English stand as leaders in this motorization race.

The last named country, several years ago, found after extensive tests that the best all-around prime mover for division artillery was the 6-wheel truck. By subsidizing manufacturers, they forced the production of 6-wheel trucks of suitable specifications for military use. Hundreds of these vehicles are now in actual use in the British Army.

Fortunately, in this country where government subsidies are impossible, there has been a commercial development of 6-wheel trucks, which started on the west coast, and has gradually travelled eastward. The use of this type of vehicle has increased yearly until now many of the large manufacturers of commercial trucks sell 6-wheelers of excellent design of from 3- to 25-tons capacity.

The 6-wheeler is especially adapted as a prime mover for artillery because the weight is supported on three axles, the two rear axles being the driven axles. By using dual tires on the wheels a very large contact area of the tires with the ground can be obtained. This means a small ground pressure per square inch. Hence, the truck wheels will obtain good traction and can negotiate soft ground or sand. Furthermore, with the 6-wheel type of truck it is possible to use a light steel track between the rear wheels so that the ground pressure per square inch can be reduced still further. Such a track of very light weight made of welded alloy steels has been developed at Watertown Arsenal. It can be applied or removed in about five minutes. It should be used only when passing over ground so soft that the vehicle would not otherwise be able to traverse it. Fig. 7 shows a 6-wheel truck of the size and type suitable for division artillery with the 75-mm. universal carriage being trailed behind the truck.

The new universal carriage is of such construction that it can be readily lifted aboard the truck discarding the wheel and axle assembly and removing the four outriggers which would also be carried on the truck. It has been computed that the mount could be put in a firing position from the truck or reverse under favorable conditions in five minutes. This arrangement (Fig. 8) reduces the road space by one-half as will be seen from the illustrations. The lifting gear for placing the gun mount on or off the truck would be carried on the latter. The weight of this lifting gear would be less than the weight of the discarded wheels and axles.

Fortunately, the new 105-mm. howitzer which gives a maximum range of 12,000 yards for a muzzle velocity of 1,550 ft.—seconds can be mounted on the 75-mm. universal carriage which nas been described. The howitzer so mounted can fire through 360° traverse and at a maximum elevation of 80°.

In conclusion, the division artillery in the next war will be entirely different from that used in the last war. It must be designed and built with the idea of being capable of attacking swiftly moving targets on the ground or in the air. The gun and carriage cannot do this alone. They must be supported by mechanical and electrical fire control, which will compute, instantaneously, accurate data for moving targets in the air or on the ground. The artillery must be capable of being drawn by high speed trucks, which must possess cross-country mobility.

That we are living in a machine age often has been stressed. We would be remiss under this condition not to adopt, manufacture and be proficient in the use of the best machines incident to the mechanization of armies provided they are sufficiently better than present models to warrant their cost. Such a conclusion follows from the fact that the Army is a constantly functioning research laboratory.

Increased Bullet Speeds

Effects and Possibilities of a German Rifle and Its Ammunition

By H. Gerlich*

IN accepting the invitation received from the Editor of ARMY ORDNANCE, to contribute an article from my own pen with reference to certain results obtained in my research work, it is my first duty to express my sincere gratitude for this foreign appreciation of the scientific and practical work I have been able to perform in the way of improving the ballistics and the efficiency of the modern rifle cartridge and the rifle adapted to it. The actual success consists in the practical realization of a somewhat decisive increase of the radius of effective action of the cartridge and the rifle it is fired from and also in a telling increase of its effects.

In making my technical statements I am doing so as a rifleman and hunter as well as an engineer. Having been born in St. Louis, Mo., I am not altogether a complete stranger to the United States and American sportsmen and engineers. In receiving the hospitality of the pages of ARMY ORDNANCE, I am availing myself of this opportunity as a man and rifleman, who is doing his work for the value of the thing itself, because he is driven to it by his innate love for the groved tube, which a gracious Providence has been putting into the hands of men. I do so for the sake of scientific and practical research and progress and with the declared intention of improving the ballistics and efficiency of military fire arms.

RIFLEMEN all know the slogan: Once a cartridge-maker always—a liar. However, even gun and cartridge history has a moral for the state of perfection of arms is more than a fair index of the degree of general technical development reached. Indeed it is so for so-called human civilization, if not culture. And history is frequently not only stranger than fiction, but is certainly more interesting.

Being well aware that traditions are hard to break and that prejudices of old established custom die hard, the author will make no claims whatever in the following remarks, but will limit himself, as far as possible, to stating mere facts and the results of actual, practical tests carried out minutely and with the aid of modern instruments of precision under the control of independent experts or the observations made in the field by practical game-hunters. Readers should not expect any wisdom here unless supplied by their own conclusions.

A practical game and target shot since his earliest boyhood, the son of a man, who shot wapiti in Wyoming and bison in the western prairie lands more than 60 years ago, who hunted near the sources of the Nile before the Mahdi shut off these regions from the so-called civilized world and who shot tigers and big game in India later on whilst holding a high official position in Calcutta, the writer has inherited to the full that love for the hunt and the hunter's noblest arm, the rifle. Being an engineer and a specialist in thermodynamics he has, during several decades devoted at least part of his time and professional work to the improvement and development of the rifle and its cartridge.

He was utterly convinced all the while, that as a real tool of precision, and with regard to really far-reaching effects, even the most efficient of our modern Nitro-express-rifles were still in their infancy and a long way from fullfilling even moderate aspirations. Indeed it is the writer's firm belief, that only very few people have but even a vague imagination as to how far our high-velocity, flat-trajectory rifle and its cartridge may be developed as a tool of precision and as a conveniently handled arm of range, power and efficiency. His own aims went for this goal and he has the satisfaction, that he has been able to realize so far at least a certain preliminary practical step in this direction in spite of his very limited private means and time and that for once—in using the words of Major Pollard, London,—private sporting design has taken in various respects the lead and precedence over military design.

THE so-called Halger .280 H. V. Magnum cartridge and its bullets designed and developed by the writer are but a preliminary step towards further and more important developments. In spite of this fact the extent of the sudden progress made ballistically with the present Halger cartridge is in actual practice in several respects very telling indeed and partly even highly decisive, quite apart from the numerical increase of the velocity and energy figures. The caliber of 7-mm. was chosen because of its specific ballistic qualities in a small arm and for other considerations as well. The writer is not at all surprised by certain antic-

Fig. 1. Halger .280 High Velocity Magnum Rifle With Zeiss-Zielsechs Telescopic Sight.
The straight stock and somewhat lengthy pistol grip on this specimen are especially designed to the author's style of shooting.

*Engineer, Kiel, Germany.

ipations with regard to definite drawbacks, which, in the light of present practice and experience, are seemingly inseparable from a cartridge and rifle of this type and power, i. e., in connection with bullet velocities of up to 4,000 ft.—sec. Many years of hard and extensive practice with cartridges of the same or similar types have proved these anticipations to be without foundation for with the aid of corresponding devices, materials and construction these drawbacks and difficulties may be eliminated and overcome successfully. The Halger-Magnum cartridge and rifle has been designed exclusively as a sporting rifle, although, naturally, conclusions may be drawn from it in other directions.

The writer, in the course of his experiments and during a period of many years, has fired personally some 25,000 or more rounds from rifles of this type on the testing stand, on the target range and in the hunting fields. For the last two and a half years an appreciable number of Halger-Magnums have been used in the hunting fields of many countries by experienced hunters and experts of the most exacting type. The writer himself or his coöperators on the testing ranges, etc., never had even a single burst case, although in a few instances some season-cracking at the mouth of the cases has been observed.

The writer's own expectations have partly been appreciably surpassed with regard to efficiency on game of these cartridges and so far not a single case has come to his knowledge, that a piece of game hit at all has not come to bag. Hunters are stating, that all game even not hit in a vital spot comes to bag quickly. The writer to a certain extent looks upon this fact as being another proof of the correctness of the fundamental ballistic principle, that not only trajectory and accuracy are inseparably joined but that also trajectory and effect stand in closest relation to each other. The cartridge, which represents the acme ballistically, at all events offers the opportunity to obtain from it a maximum also with regard to average reliability of effect on game even within enormously extended limits of effective ranges.

AS samples of what a cartridge and rifle of this type are capable of doing in point of absolute accuracy, three targets made by the writer when testing new Halgers previous to delivery at the Berlin Small Arms Testing Station and under the control of the station officials are reproduced (Figs. 2, 3 and 4) in actual size. It may be stated that, as per publication of the Testing Station itself the Halger rifles officially tested at the station when brand new and fitted with all sorts of stocks, sights, trigger-pulls, etc., and testing them under all sorts of weather conditions, averaged in the accuracy test a 5 shot group at 100 meters (110 yards) a diameter of circle including centers of all 5 shots of but just about 1 inch.

The ballistics, as confirmed by repeated tests as well as the observations made in the hunting fields, actually prove that the effective and reliable killing range, i. e., the range at which the striking velocity of the bullet warrants in practice the required higher degree of shock intensity and explosive hydrodynamic effect upon animal tissue (approximately 2,500 ft.—sec. or at least 2,400 ft.—sec.) has been fully doubled by the Halger—without counting the increased intensity of effect over the shorter ranges. At the same time —and apart from the accuracy, this new cartridge guarantees a minimum of deviation from the line of aim (trajectory almost coincident with line of aim even over extreme hunting ranges) and the shortest time of flight so far realized with a small-arm. Therefore, it establishes a most decisive increase of practical accuracy in the hunting fields and even at the target, which is entirely due to the increased initial velocity of the bullet combined with its markedly increased ranging characteristics. The practical accuracy, however, is what counts decisively in hunting practice and also in warfare.

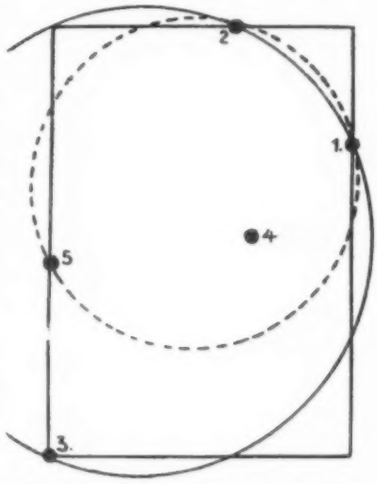


Fig. 4. One-quarter Actual Size Reproduction of 5-Shot Group With Halger .280 H. V. Magnum.

Made at 1000 meters (1094 yds.), using 180-grain iron-jacketed and nickel-plated bullet; initial velocity 3043 ft.-sec.

Halger bullets fired at Halger speeds are influenced by atmospheric conditions, wind, etc., relatively much less than any other small-arm missiles. They keep their mean points of impact, which in Halger-Magnum magazine rifles are regulated in such a way, that up to 300-350 yards the impacts of the three bullets practically coincide with the same sight setting and same point of aim, and not only show an extreme absolute degree of stability in flight, but also become highly stabilized with increased quickness and within a much shortened distance from the muzzle of the rifle. Hence the marked relative increase of the value of their ballistic coëfficient, which reaches in the 180-grain Halger bullet a maximum thus far obtained from any small-bore bullet (at least up to a range of about 2,200 yds.).

The ballistics of the three Halger bullets up to 300 meters (328 yds.), as determined by special tests carried out by the German Testing Station for Small-Arms of Berlin-Halensee and obtained with Halger .280 H. V. Magnum cartridges of present commercial loading from a Halger Magnum rifle fitted with a 28-3/8-inch barrel, are shown in Table I.

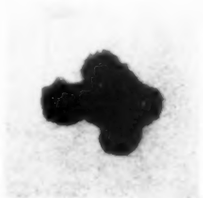


Fig. 2. Full Size Reproduction of 5 Shot Group with Halger .280 H. V. Magnum Magazine Rifle.

Made at 100 meters (109.4 yds.) using 100-grain bullet, initial velocity 3815 ft.-sec.; mean velocity, over 109.4 yds., approximately 3600 ft.-sec.

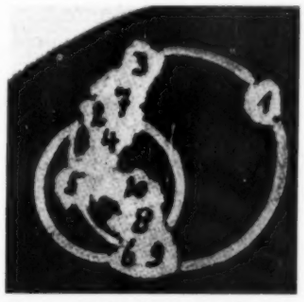


Fig. 3. Full Size Reproduction of 10 Shot Group With Halger .280 H. V. Magnum Double Rifle.

Made at 80 meters (88 yds.) using 180-grain gilding metal jacketed bullet, initial velocity 3043 ft.-sec.

TABLE I.

Velocities in ft.—sec.	At the Muzzle	At 100 Meters (109.33 yds.)	At 200 Meters (218.66 yds.)	At 300 Meters (328 yards)
100-grain bullet..... (Sectional density = 16.5 gram.—cm²)	3900	3360	2930	2510
145-grain bullet..... (Sectional density = 23.9 gram.—cm²)	3500	3260	3070	2900
180-grain bullet..... (Sectional density = 30.5 gram.—cm²)	3043	2903	2800	2700
Energies in ft.—lbs.				
100-grain bullet =	3320	2480	1875	1374
145-grain bullet =	3880	3380	3000	2655
180-grain bullet =	3690	3355	3125	2910

It is well to compare not only the striking energies of these bullets at the various ranges with others of various calibers, but especially the striking velocities. It may also be noted, that the time of flight, for instance, of the 100-grain Halger bullet over the first 200 meters (218.66 yds.), amounts to less than 0.2-sec., which means an average mean velocity of this bullet over approximately the first 220 yards of over 3,300 ft.—sec. This 100-grain bullet giving a highly reduced barrel-time combined with a minimum of barrel and rifle reaction in the way of barrel vibration and recoil and becoming quickly stabilized after leaving the muzzle is partly due to these causes. It is capable of extreme accuracy at even very short ranges and up to about 350-400 yards and even further. It may sound strange to some fellow-riflemen, but it is a fact nevertheless, that this bullet is a dependable performer even at 328 yards, i. e., the international free rifle distance.

WITH regard to erosion in a rifle firing a cartridge of this type, as well as with regard to metal fouling in connection with velocities of up to 4,000 ft.—sec., a practical rifleman would have at least certain misgivings at the start. So had the writer. To state the facts bluntly: undue erosion has been avoided in this rifle and with this cartridge by the use of a stable and relatively very cool burning, pure nitrocellulose propellant of a high specific density and a highly progressive character.

The residues of these pure nitrocellulose propellants are slight and are, as proved by chemical analysis, nothing but harmless ash entirely indifferent to steel. Besides, the patented method of regulating the cartridge with its three different bullets in connection with the chambering and boring of the barrel prevents all gas leakage past the bullet from its start from its seating in the cartridge neck and seals the bore reliably during the whole passage of the bullet. At the same time Austrian and German steel chemists have not been idle and have put at our disposal improved compound steels for rifle barrels, which not only combine a high degree of elasticity and hardness, but which also excel by their special properties of resistance to corrosion and heat. No doubt, the exact machining of these special compound steels is harder and more expensive, as is the cost of these materials themselves over that of most present standard barrel steels, still the difference in price is certainly not so high as to prevent them being used for the purpose.

The writer has in his own possession Halger-Magnum rifles, from which more than 2,500 rounds have been fired—and partly experimental loads giving increased pressures and velocities—the special steel barrels of which have not altered anywhere in their bores and especially not at their leads more than 0.005-0.01-mm. (0.0002-0.0004-inches) from their condition when new. These barrels will not be shot out, but—if spoiled—are, as with most other barrels, as a rule cleaned by improper cleaning methods and unsuitable cleaning tools.

Metal fouling in a rifle firing jacketed bullets is more or less always present and indeed even at low velocities. Iron jacketed bullets correctly nickel-plated (with a slight percentage of copper as, for instance, that has been used for decades in the German military 154-grain Spitzer bullet, which is fired with a velocity of almost 2,900 ft.—sec.), do not have in themselves the same tendency to foul the barrels, as is the case with most cupro-nickel jacketed or similarly jacketed bullets of American or English manufacture, nor do they build up metal-fouling to a higher degree. This is a proved fact. It may also be mentioned that the so-called gilding-metal jackets as used, for instance, in the new American service and sporting bullets, behave satisfactorily in carefully bored rifle barrels at velocities up to about 3,000 ft.—sec. But so far as practical experience seems to show, velocities exceeding these speed limits to a greater extent the U. S. gilding metal alloy, for instance, becomes less satisfactory or even unsatisfactory in its behavior.

This, however, is not the case with an iron-jacketed and correctly nickel-plated bullet fired with a relatively cool-burning propellant and from a carefully constructed and properly polished barrel, which in its construction and finish warrants a minimum of bullet deformation and friction. We have certainly not yet reached the millenium in this respect, but it is a proved fact, that today bullets may be fired with 4,000 ft.—sec. and more with actually much less metal-fouling of the bore, than has been possible heretofore at velocities in the neighborhood of but 2,500 ft.—sec. or even appreciably less. It should also be pointed out, that bullet friction and metal-fouling of barrels does not increase in direct proportion with the speed of the bullets and that in fact when certain speed limits are reached both absolute friction and metal-fouling—in analogy with similar physical phenomena—are appreciably decreasing. Besides, there have been developed oxidizing ammonia swabbing solutions which are harmless to the bore and efficiently remove nickel and copper-fouling as well as all primer salts.

Questions with regard to muzzle blast, noise and recoil of the Halger-Magnum could better be answered by an unbiased user who has had an opportunity to shoot the rifle and watch its behavior in these respects. Indeed the report of the King's Prize Winner at Bisley 1928, Mr. Arthur C. Hall, with regard to recoil, muzzle-blast and noise of the Halger .280 has been published in *Country Life*, London (March 16, 1929). The slight recoil of the Halger, especially in relation to its high muzzle energy, as felt by the marksman is a special feature of this rifle and cartridge and it is because of this, that full advantage of the extreme accuracy of this rifle and cartridge is rendered possible. The shot that counts, is only the shot that hits.

THE anticipation that probably there is a snag somewhere and that the advantages of such a cartridge and rifle cannot probably be reaped without a certain compensating disadvantage, is perhaps partly correct. This disadvantage, however, is not a technical one, but one of expense

and the necessity of highly skilled and accurate manufacture.

No doubt, bullets of this type and caliber may be modified into armor-piercing bullets in following the usual construction of such bullets. However, quite apart from possible developments and modifications along these lines, from which certainly in connection with Halger bullet-speeds a very telling and appreciable increase of penetration may be obtained, the writer may be allowed to touch upon certain observations made by himself and his assistants when developing certain cartridges and bullets possessing highly increased speeds. The observations made with regard to certain bullet effects upon hard objects capable of giving a maximum of resistance against bullet penetration are highly characteristic and invite conclusions which no doubt will greatly interest all readers of ARMY ORDNANCE.

When running the tuning-up trials for the fixing of the commercial loads of the Halger-Magnum cartridge in connection with the 100-grain bullet a load was tried, which imparted a velocity of some 1,250 meters—sec. (Some 4,100 ft.—sec.) to this bullet of very light absolute weight and possessing a sectional density of but 16.5 gram.—cm². With the first bullet fired against the contact plate at a distance of 50 meters (55 yards), the current of the Le-Boulenge was interrupted and it was found, that one of the 5/8-inch bolts fixing the contact plate had snapped off clean without showing the least trace of any anterior flaw, but being perhaps a trifle short in grain.

Besides it was found to the astonishment of the writer's assistants, that the sharp, hollow copper point of the bullet, which was as thin and even thinner than the paper upon which ARMY ORDNANCE is printed, and which covered the expansion hole at the point of this mushrooming sporting bullet, had penetrated from 1/4- to 5/16-inch into the contact plate, which was new and made of the hardest Krupp armor plate. This plate being 1 1/4-inch thick and about 2 by 2 feet was a heavy one and its surface was glass-hard. In spite of this fact the fragile, hollow Spitzer copper point of this bullet, which may be deformed with a finger-nail, had made an indentation about 1/4- to 5/16-inch deep into the armor plate of practically the very same shape as the bullet's point. Indeed the form of this entrance of the bullet point into the plate looked like a casting-form or an actual negative of the bullet's point. At the same time the surface material of the plate was pounded away around this point of impact in a rather circular area of about 1-inch diameter and to a depth of about 1/16-inch and deeper.

No similar bullet effect upon such a plate had ever been observed previously, although many bullets with appreciably higher striking energy had been fired against such a plate. Nor were such effects observed with the 145-grain and 180-grain Halger bullets, which had just previously been fired against the same plate and the energy of which appreciably exceeded the striking energy of the speedier 100-grain bullet. Some 5 or 6 more 100-grain bullets were fired against the plate after this and then the plate controlled once more with the same observation made as with the first shot. The heavier bullets hitting the plate with a higher energy but at a lower speed had disintegrated upon the surface of the plate without entering into it at all and leaving but the usual whitish splash mark, whilst the speedier lighter bullets always penetrated into the glass-hard armor plate in the manner described. After a few more shots thrown upon the plate irregular pieces of walnut size began to drop out of the surface of the plate around the spots where Halger bullets had struck it and with about a dozen such Halger shots the whole plate had been fairly wrecked! The writer's assistants, looking askance at this phenomenon, were at a loss to understand how such a fragile bullet could possibly show such disastrous effects upon a dead-hard armor plate.

The explanation, however, seemed to the writer easy and plausible enough. Undoubtedly, a critical striking velocity had been reached with the little bullet and owing to the very high velocity, with which the bullet struck the surface of the plate, the dynamic process was so sudden and intense, and so-to-say "timeless," that there was no time left for the physical properties of the two bodies, i. e., the fragile bullet point and the glass-hard steel plate, to show up in the usual way. The effects of physical elasticity of the two bodies could not materially show up under these circumstances and there was no time left for the elasticity and plasticity of the materials to assert themselves. Even a very soft and plastic body becomes relatively unyielding, dead-hard and actually unelastic when the dynamic process becomes accelerated to such a degree, that the time is no longer available to render possible the effects of the physical elasticity and plasticity of materials. *Cum grano salis:* The Einstein theory of relativity in a mechanical-dynamical sense.

The writer may be allowed to call to the attention of the readers of ARMY ORDNANCE his statements and deductions made in connection with these observations in his article entitled "*Leistungssteigerung der Infanteriewaffen, Geschossgeschwindigkeit und Taktik*," published by Generalleutnant M. Schwarte (editor) in the German military-technical paper "*Heerestechnik*" (No. 9, September, 1929). He considers it also his duty to recall certain investigations and statements of Captain Tressidder made more than 30 years ago with reference to the specific performance of projectiles striking at different velocities and his specific distinctions in connection with so-called "critical" striking velocities. Although Captain Tressidder's valuable investigations referred almost exclusively to large bore, capped projectiles of naval guns, and moreover, practically only to the specific behavior and effects of such bullets striking armor-plate about normally at right angles, they are nevertheless even now quite actual and of special interest to riflemen and students of infantry arms. This in spite of the fact that Captain Tressidder's tests and observations were naturally limited to lower speed limits—as bullet velocities of more than about 2,800 ft.—sec. or so were, according to the writer's knowledge, not available to him.

A point worthy of special attention is the observation made in the course of the writer's trials with highly increased bullet speeds that, apart from their marked insensibility against being diverted from their line of flight by obstacles, they would "bite" and penetrate into very hard materials, such as granite blocks, even when striking their surface oblique and at very small angles. They did not ricochet and were not diverted without performing noticeable work of destruction on such hard and resisting objects, as would have been the case at lower striking velocities. They "blasted" these rocks or at least partly smashed them even under such severe conditions. Since

soft-cored, hollow-point sporting bullets were used under these circumstances the bullets disintegrated entirely and were practically pulverized when striking at small angles—not however without performing destructive work of the nature described. This was, for instance, the case with a 100-grain bullet driven at 4,100 ft.—sec. in connection with an experimental Halger .280 load, which proved to be highly accurate at the same time.

Similar effects have been observed regularly with these bullets fired even from standard commercial Halger cartridges against granite stones at ranges from about 60 to 100 yards, when such freely deposited stones will actually be blasted or detonated by a single such bullet and indeed with the noise of a blast-shot. Bullets striking with lower velocities—even being appreciably heavier and carrying much more striking energy—will not be able to render effects of such character and intensity.

IT is not a matter of caliber and bullet energy or bullet weight and mass, but in the very first instance a question of bullet velocity. The correctness of this assertion—in a physical sense—has only quite recently been proved again ballistically by another sporting, i. e., big game, cartridge and rifle developed by the writer. This is his new Halger .335 H. V. Super-Magnum cartridge, which is fired from a rifle weighing, even with a long barrel, 9 1/4 to 9 1/2 lbs. and possessing a perceptible recoil not heavier than that of a standard 8- or 9-mm. rifle firing bullets of some 220 grains weight at an initial velocity of about 2,000-2,100 ft.—sec. This rifle has been designed and developed in order to substitute efficiently the ancient large bore and overheavy cordite big game rifles with relatively low bullet speeds and moderate accuracy even at short ranges. Notwithstanding a muzzle velocity of 3,125 ft.—sec. and an energy of 5,220 ft.—lbs., this 240-grain (sectional density = 27.5 gram.—cm.^{2}) b. t. copper-pointed or full metal-jacketed bullet is quite incapable of competing with, for instance, the little 100-grain Halger .280 H. V. Magnum bullet (commercial cartridge) possessing an initial energy of but 3,320 ft.—lbs., at however 3,900 ft.—sec., with regard to its specific destructive effects upon armor plate.

Fig. 5. The Halger .335 H. V. Super-Magnum Cartridge (Actual Size).

Probably the new Halger .244 cartridge and extra-light weight rifle, which is now being developed, firing a very light bullet at much higher speeds will be far more interesting in this direction. The 300 meter trajectory of the 240-grain b. t. .335 Halger bullet over line of sight when using a telescopic sight is but exactly 5 inches and the ballistic performance of this powerful new cartridge may be judged by the results and figures obtained during the official tests. These were published by the German Testing Station for Small Arms at Berlin-Wannsee in its technical paper *"Kugel und Schrot"* (No. 24, December 15th, 1929). Apart from the splendid showing made in point of accuracy up to 328 yds. the results were as follows:

Distance:	Muzzle	100 Meters	200 Meters	300 Meters
V in ft.—sec.	3125	2888	2678	2482
V in ft.—lbs.	5220	4455	3833	3284

It is the writer's firm belief, based upon theoretical and mathematical considerations as well as upon actual observations with still higher bullet speeds, that in future even riflemen will use but one standard and simple form and construction of bullet for shooting all sorts of game and that they will do so with far more reliable effects and even at much longer ranges than is today possible even with the most suitably adapted sporting bullets of the mushrooming and expanding, etc., types. These standard sporting bullets of the future will be fully metal patched or solid bullets—fired with initial and striking velocities much in excess of what so far has actually been realized in the way of bullet speeds. Under such conditions the question of caliber and the disadvantages of the present, fully jacketed, military small-bore bullets, which in connection with the heretofore usual striking velocities are piercing but not smashing, shocking and stopping bullets will be eliminated.

The question put to the writer, whether an approximate 4,000 ft.—sec. initial bullet speed is the limit or whether some further improvement in propellants and bullet design will transcend this figure, may be answered without fear of committing one's self to an erroneous prophesy. This limit will most surely be exceeded and indeed the writer himself is in a position to admit, that he is exceeding the 5,500 ft.—sec. limit and is drawing near a still higher speed stage with bullets and cartridges with practically standard sectional bullet densities! Even if sportsmen will not require such ultra-high velocities, the military are bound to do so in time and especially in connection with machine guns mounted on aircraft and also for larger guns and antiaircraft guns to be used from the ground. To the writer it is astonishing that, even now, no higher bullet velocities have been realized in connection with such guns and even with large naval guns.

IT is scarcely doubtful any longer, even to the uninitiated, that in future military services will be compelled to adopt a somewhat smaller caliber for their infantry rifles, which so far still adhere to a bore in the neighborhood of .30, or about 8-mm. A caliber from about .250-.280, i. e., about 7-mm. or even somewhat less, and bullets of absolute light weight will—for many obvious reasons—surely be chosen in connection with the self-loading military rifle, which in time is bound to be generally adopted by the military powers. Several arms of this type and bore, firing bullets of appreciably less absolute weight and even less sectional density than used heretofore, have been developed by some of the world's leading armor firms and have been tested quite successfully. They are, ballistically, about on even terms with the majority of present military cartridges and bullets.

However, the writer's view is, that all these rifles and at least cartridges, whatever their present specific advantages—if adopted in the near future—stand a wonderfully fine chance of becoming obsolete and superseded before even the respective governments will have been able to arm part of their troops with them. These present arms are insufficient ballistically—in the light of research and development—and with regard to their specific destructive powers

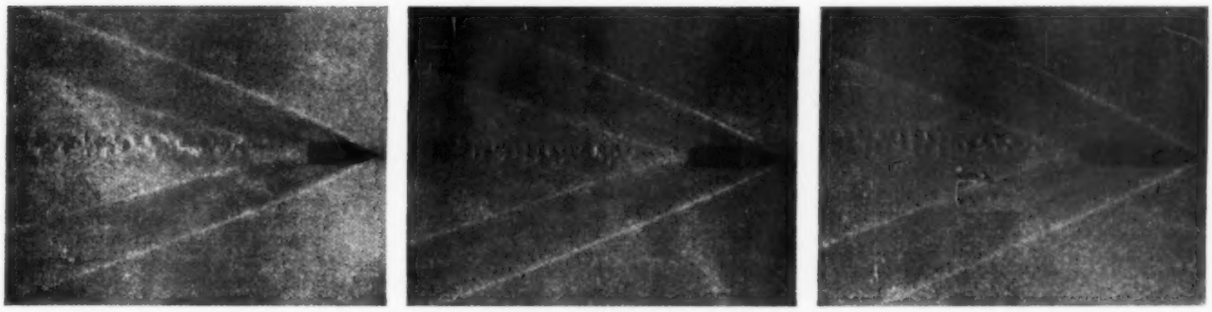


Fig. 6. Halger .280 Bullets in Flight.

Left: 100-grain flat-base bullet, 3815 ft.-sec. initial velocity. Center: 143.5-grain streamline bullet, 3500 ft.-sec. initial velocity. Right: 180-grain streamline bullet, initial velocity 3043 ft.-sec.

against armor plate, tanks and other modern machines of war. They do not enable the infantryman efficiently to fight against such modern machinery, even at short ranges, with his capital arms, his rifle and his machine gun. This advantage, however, should be given him and should be considered a necessity under the conditions of modern warfare. The successful realization of this is, judging by the writer's latest ballistic attainments, quite within the grasp of modern technique and, indeed, in connection with arms certainly not more cumbersome, bulky or more weighty than our present rifles and guns.

For technical and ballistic reasons various scientific tests have been carried out with the Halger .280 H. V. Magnum wherein angles of elevation, i. e., trajectories, were controlled on the range up to and including the distance of 2,000 meters (practically 2,200 yards).

The accompanying pictures (Fig. 6) show the three Halger bullets in full flight. These three bullets differ greatly from each other in weight, form and initial velocity, but may be fired from the same rifle with practically the same mean point of impact up to longest hunting ranges with the same sight setting and without changing the point

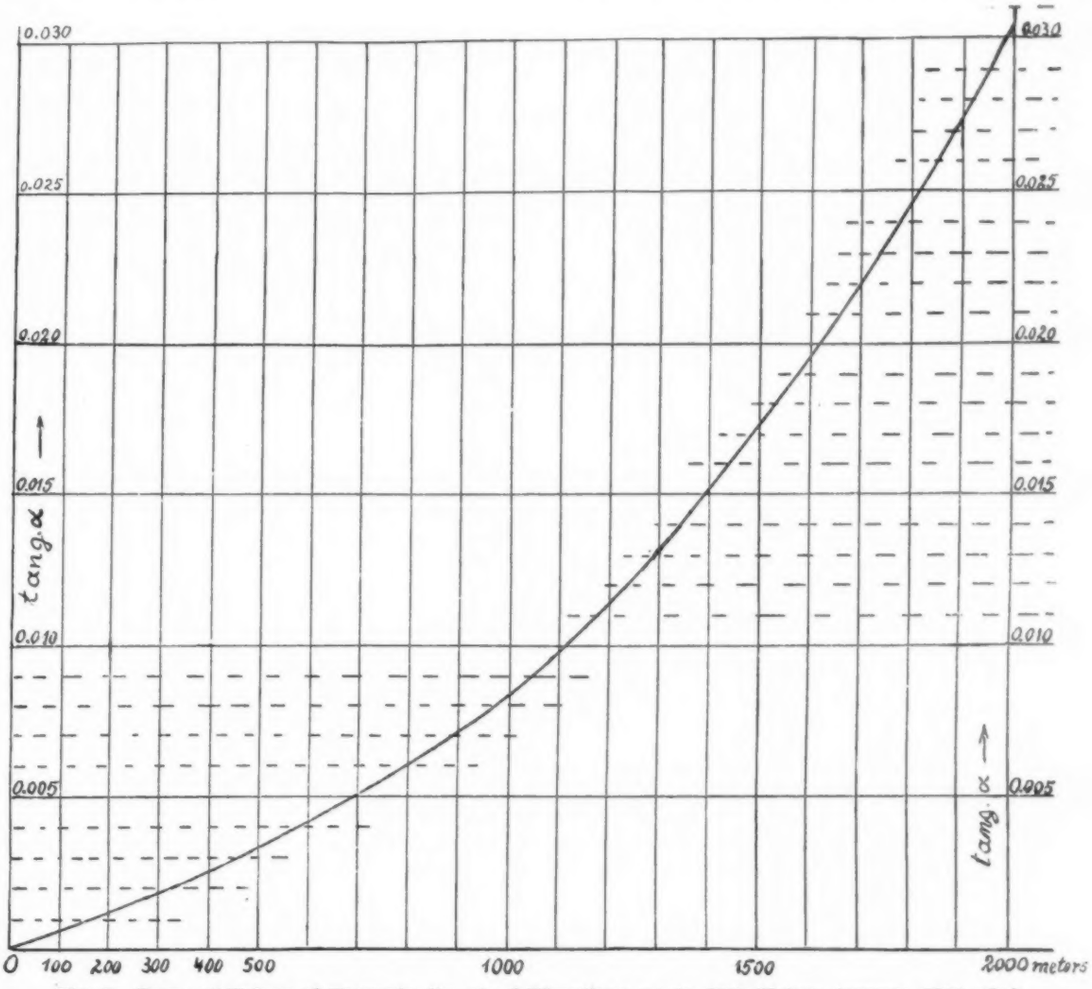


Fig. 7. Curve of Values of Tangents (tg. a) of Elevations up to 2000 Meters (approx. 2200 yds.)

For the 180-grain Halger .280 H. V. Magnum sporting streamline Spitzer bullet fired from 28⅜-inch barrel, initial velocity 3043 ft.-sec.

TABLE II.—Table of Elevations

Meters	Halger .280 H. V. Magnum 72-cm. Halger Barrel			German Service Cartridge, Cal. 7.9 mm. 74-cm. Service Barrel	
	180-grain (Sect. Dens. 30.5 g.—cm².)	143.5 grain (Sect. Dens. 23.9 g.—cm².)	100-grain (Sect. Dens. 16.5 g.—cm².)	154-grain (Sect. Dens. 20.4 g.—cm².)	198-grain (Sect. Dens. 26.3 g.—cm².)
400	8′36″			9′20″	10′
500	11′24″			13′40″	14′20″
600	14′36″	10′10″	12′30″	19′20″	19′20″
750	19′ 4″				
900	24′10″	20′	36′ 5″	43′00″	39′55″
1000	28′45″	24′50″	47′42″	53′40″	48′10″
1200	39′39″	35′55″	1°18′10″	1°20′50″	1° 7′35″
1250	42′20″				
1500	59′30″	1° 0′45″	2°29′30″	2°16′50″	1°44′50″
1750	1°20′26″				
1800	1°24′40″	1°33′45″		3°35′40″	2°32′35″
2000	1°44′50″	1°58′45″		4°43′20″	3°10′20″
Vertexes of 1000 m. =1100 yds. trajectories	= 2 m.	1 ¾ m.		6 m.	5 meters

of aim. Besides the relative tuning-up of the three loads it is, of course, the high bullet stability and the absolute degree of flatness of the trajectories, so far never obtained with small arm bullets, which render such a result possible.

The ballistics of the 100-grain Halger bullet have in the meantime been further improved somewhat with a new load of a somewhat differently tuned-up propellant, so that it now starts with an initial velocity of 3,900 ft.—sec. when fired from the commercial Halger cartridge and from a 28 3/8-inch Halger barrel.

The recent tests up to a distance of 2,000 meters were started at a range of 400 meters and the distance was then gradually increased by 200 meters up to 1,200 meters. At each distance 8 shots were fired. Thereafter the distance was successively increased to 1,500 meters, 1,800 meters and finally to 2,000 meters or just about 2,200 yards. Twelve shots were fired on each of these three longest ranges. There was no intermediate cleaning of barrel during the test. The Halger-Magnum rifle used in this test was fitted with a 28 3/8-inch non-rusting Böhler Antinit N. G. steel barrel and, owing to the mountings for a telescopic sight—which, however, was not used in this test—the Mod. 98 German military curve-sight (German service sight) had to be placed rather forward on the barrel thus reducing the sight radius appreciably and increasing errors of aim correspondingly.

The aiming was done with this service, iron backsight and standard military foresight. In spite of the shortened sight radius and using the rough, service iron sights the maximum spread of the Halger 180-grain bullet, at the maximum 2,200 yards, with which the test was concluded, amounted to barely 6 minutes of angle. The same man fired at all ranges in quick succession. The firing was done from the shoulder (sitting) and the fore end of rifle rested on a cushion.

The curve of the values of tangents (tg. a) for the 180-grain and 143.5-grain Halger bullets up to a distance of 2,000 meters, or just about 2,200 yards, as found by actual firing, with corresponding angles of elevation added, appears in Fig. 7.

An elevation of 1° gives a horizontal range of 1,520 meters, or 1,665 yards, for the 180-grain Halger .280 H. V. Magnum bullet.

For comparison's sake the angles of departure are also given in the above table for the German military 154-grain, flat-base Spitzer bullet of 7.9-mm. caliber (sectional density = 20.4 gram.—cm²) and for the new German 198-grain military long-range, stream-line Spitzer bullet of the same 7.9-mm. (.311-inch) caliber (sectional density = 26.2-gram.—cm²). These two German service bullets are fired from standard military barrels 29 1/4-inch long with initial velocities of 2,862 ft.—sec. and 2,533 ft.—sec., respectively, according to official "Regulations for heavy machine guns H. Dv. 73."

For the sake of further direct comparison the elevations in minutes of angle are given below for the latest officially adopted service bullet of high ballistic efficiency, i. e., for the United States 172-grain (sectional density = 24.55 gram.—cm²), caliber .30 boat-tail Spitzer bullet, fired from the U. S. A. Mark I 1927 service cartridge in a 24-inch barrel with an initial velocity of 2,700 ft.—sec.:

400 yards = 364 m = 11′
500 yards = 455 m = 14′
600 yards = 547 m = 18′
700 yards = 638 m = 23′
800 yards = 730 m = 27′
900 yards = 820 m = 32′
1000 yards = 910 m = 37′
Vertex of 1000 yards = 910 meters trajectory = ca. 4 ½ meters.

Index to Army Ordnance, Volume X

This, the May-June issue of ARMY ORDNANCE, completes Volume X. An index to Volume X, arranged alphabetically and by subject and author, including title page for binding, will be available shortly for members and subscribers and may be obtained without cost from the Editorial Office of ARMY ORDNANCE. Readers who have the Journal bound for permanent record should have the index and title page for this purpose. Requests for copies should be addressed to:

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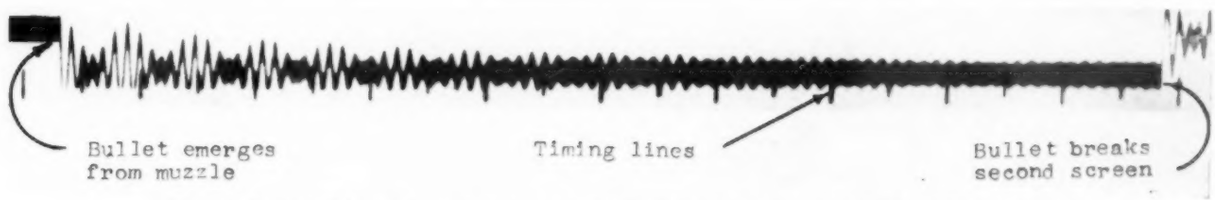

Fig. 1. Typical Velocity Record Made with the Oscillograph and Special High-speed Camera.
The spaces between the short vertical lines represent time intervals of approximately one thousandth of a second.

Velocities of Muzzle-Loading Rifles

Modern Measurements Applied to Early American Arms

By Philip P. Quayle*

THE story of the Kentucky rifleman at Fort Meigs who, in 1812 with his flint-lock rifle, shot an Indian sniper across the Maumee River, was told in the columns of *The American Rifleman* by Capt. W. H. Richards in the issue of January 1, 1926. This feat was received by many with, to say the least, a considerable amount of salt. Others doubted that a flint-lock rifle would even carry to such a range, not to mention hit its mark. In regard to this latter group of skepties the editor of the *Rifleman* at that time described them as individuals "who had never enjoyed the privilege of firing a rifled flint-lock in good condition, with the bore clean, and the flash hole or vent not rusted away to three or four times normal size" and whose observations in regard to the flint "Kentucky"[1] were limited "to a few dilapidated and rusty specimens of army muskets."

Some time after the appearance of Captain Richards' story in the *Rifleman*, Mr. Walter Cline of Chattanooga published, in the same journal, an account of some flint-lock rifle range tests which he had conducted in the presence of a considerable number of witnesses. These tests established indisputably that a flint-lock rifle was quite capable of a range of 600 yards. No claim was made in Captain Richards' story that the rifleman referred to could have repeated his lucky shot every time or even once in every ten times, but for that matter it would be most difficult to hit a similar target every time at a range of 600 yards with the *average* Springfield and *average* factory loaded ammunition.

The point is that these old rifles, properly loaded, had a muzzle velocity which rendered them perfectly capable of carrying 600 yards without too great a dispersion to prevent a reasonable chance of hitting the target in question. At the shorter ranges, say 200 yards or under, it is highly probable that some of the most accurate shooting which has ever been done was accomplished with muzzle-loading rifles. Within a week of the time this was written Mr. Cline showed to the author the targets of a 60-yard, muzzle-loading rifle match recently fired near Chattanooga in which fourth place went to a man the center of whose bullet was roughly one-eighth of an inch from a fine cross cut on a wooden board with a knife blade. So much for the accuracy obtainable with a muzzle-loading rifle in good condition.

A CONSIDERABLE amount of reliable data is available with regard to the accuracy of these old arms but almost nothing exists in the way of the actual muzzle velocities obtainable from them. This lack, however, is easily understood when it is realized that no strictly precise method of measuring muzzle velocity or any other similarly rapid terrestrial velocity existed throughout the whole course of the flint-lock period, and it was only at the end of the percussion period that even the crudest forms of chronographs began to appear. Of these the Le Boulengé, originally invented by Captain Le Boulengé, of the Belgian Artillery, has survived in a modified form to the present time and is in general use for routine work by the ammunition companies and arsenals of today.

With the improvements in photography, as exemplified in the high-speed oscillograph, and a special precision tuning fork, electrically driven, it is now possible to measure velocities with an accuracy which has not previously been approached. At the suggestion of Capt. Wm. de V. Foulke, the author has undertaken to determine the velocities of certain typical muzzle-loading rifles under various load conditions.

For the benefit of those readers who may be interested in the accuracy of these measurements we will explain as briefly as we can how they were obtained, attempting not to go too much into detail. Great care has been taken to load each charge in the same manner, carefully weighing each powder charge and bullet. In cases where patches were used the precaution was taken to use the same patch-

*Chief Physicist, The Peters Cartridge Company, Kings Mills, Ohio. Captain, Volunteer Marine Corps Reserve.

1. It is to be understood that the flint "Kentucky" rifle was not made in Kentucky but in New England and Eastern Pennsylvania.

Fig. 2. The Capt. Wm. deV. Foulke Rifle with which the Tests Described in Figs. 3 and 4 were Carried Out.

ing material throughout the tests and in the case of the percussion rifles the same lot of caps also in so far as the supply at hand lasted. The apparatus was arranged to record electrically the instant at which the bullet left the rifle muzzle and its subsequent arrival at a point 20 feet away. At each of these positions the ball cuts a very small wire, thus interrupting the electric currents at those points. The circuit by which these changes in current are communicated to the recording system has no appreciable lag, or delay, in so far as these measurements are concerned. The changes in current, just referred to, are recorded on a rapidly moving photographic film and at the same time a very accurate time scale is photographed on the record as a series of short marks roughly one thousandth of a second apart in time, or, more precisely, the interval between two adjacent timing lines represents $\frac{1}{1031.0}$ of a second. A typical velocity record is shown in Fig. 1.

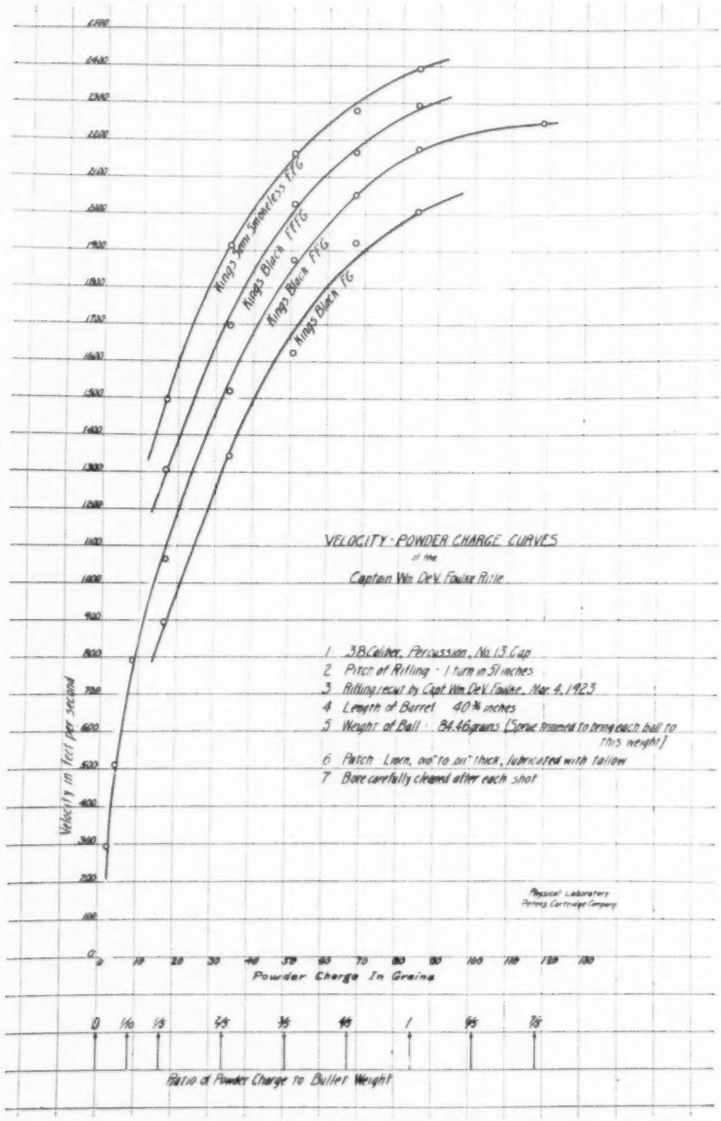
Velocity in feet per second
Kings Semi Smokeless FFG
Kings Black FFG
Kings Black FFG
Kings Black FG
VELOCITY - POWDER CHARGE CURVES
of the
Captain Wm. DeV. Foulke Rifle
1. 38 Caliber, Percussion, No. 13 Cap
2. Pitch of Rifling - 1 turn in 51 inches
3. Rifling recut by Capt. Wm. DeV. Foulke, Mar. 4, 1923
4. Length of Barrel 40⅜ inches
5. Weight of Ball: 84.46 grains [Sprue trimmed to bring each ball to this weight]
6. Patch: Linen, .010" to .011" thick, lubricated with tallow
7. Bore carefully cleaned after each shot
Physical Laboratory
Remington Arms Cartridge Company
Powder Charge In Grains
Ratio of Powder Charge to Bullet Weight

Fig. 3. These Curves Show the Velocities Obtained with Various Powder Charges in the Capt. Foulke Rifle.

It will be obvious that the percentage accuracy could have been greatly increased had we chosen to make our velocity measurements over a longer range but this involves making certain assumptions in converting such measurements into muzzle velocity. The data presented in this paper therefore represent the velocity at a point probably slightly less than 10 feet from the muzzle or the average velocity over the first 20 feet from the muzzle. For all practical purposes the velocities given in this paper may be considered as those which would be obtained at the muzzle.

Tests of Captain Foulke's Cal. .38 Rifle.—This rifle, which is shown in Fig. 2, was kindly presented to the author for these experiments by Capt. Wm. de V. Foulke of West Virginia. It has the following specifications: Caliber .38; percussion lock; length of barrel: $40\frac{3}{4}$ ins.; pitch of rifling: One turn in 51 inches; ammunition: Pure lead bullets weighing 84.46 grains—linen patches, .010 to .011-inch thick, lubricated with tallow—black powder, Kings Quick Shot, in three granulations: F. G., F. F. G. and F. F. F. G.—Kings Semi-Smokeless in F. F. G. granulation.

The bore of the rifle was carefully cleaned after each shot. This was done by first wiping out the barrel with a wet patch and then with dry patches until the bore was clean and dry. The wiping out with a wet patch softens the powder cake which forms at the breech, and to a lesser degree along the bore, so that it may be cleaned out easily with the subsequent dry patches.

The bore of the rifle was carefully cleaned .03 of a grain, which is a greater degree of accuracy than the uniformity of the powder warranted.

Each bullet was carefully trimmed down at the sprue until its weight was within .03-grain of 84.46 grains, the standard bullet weight for this experiment.

In loading, the powder charge was poured in and a greased linen patch placed on the muzzle and carefully centered. The diameter of this patch was such that its edge would be just flush with the muzzle when the ball was seated in the bore a distance of one diameter. When the patch was in position the ball was placed upon it, sprue down, and properly oriented. The bullet-starter was then placed on the ball and given a light blow with the palm of the hand, thus seat-

TABLE I
Cartridges for Small Arms, 1839

Kind	Balls		Charges of Powder				Remarks
	Diameter, Inches	Number in One Pound	Weight, Grains	Number in One Pound	Ratio to Weight of Ball	Blank Cartridges, Grains	
Musket	.64	18	130	54	1-3rd	117	Musket Powder
Musketoon	.64	18	85	82	2-9ths	77	
Hall's Musket Carbine Caliber	.64	18	75	93	1-5th	68	
Hall's Rifle Carbine Caliber	.525	32	75	93	1-3rd	68	Rifle Powder
Hall's Rifle	.525	32	100	70	4-9ths	90	
Common Rifle	.525	32	100	70		90	
Pistol	.525	32	50	140	2-9ths	45	

ing ball and patch into the rifling. Then, with the ram-rod in its guide, the ball was seated down on the powder charge with as nearly a uniform force as could be estimated.

The results of the first four tests are shown in Fig. 3, each point being the mean of three or more independent determinations, depending on the uniformity of the powder. It will be noted that the abscissa or charge axis, of the curves in Fig. 3 is laid out both in grains and fractions.

It was the custom, in the old muzzle-loading rifle days, to determine the charge of a sporting rifle by placing the ball in the palm of the hand and then carefully sifting out enough powder, from a flask or horn, just to cover the bullet; the bullet being a sphere inscribed in the cone of powder. This gave, very approximately, a weight ratio of powder to ball of 1 to 5. Captain Foulke says that he has weighed many such loads and "found them to check quite closely." This rule is, apparently, a fairly exact one but of course it would not be expected to apply with other than round balls. In this connection it is of interest to note Table I (page 406) which is reproduced from the Fire-Arms Collection Catalogue, of the U. S. Cartridge Co. It is, of course, to be understood that these data apply to the military arms of the period.

It will be seen that the average ratio of the weights of powder to lead in use with these arms was roughly one to about three and one-half. Hence, once more referring to Fig. 3, the fraction 1/5 on the horizontal or charge axis means a charge of powder equal to one-fifth the weight of the ball. Similarly 4/5 means a powder charge equal to four-fifths the weight of the ball, and so on.

These curves of Fig. 3 show some very startling things. For instance, a velocity of 2,000 feet per second was obtained with a 3/5 charge of the F. F. F. G. powder, or with slightly more than a 7/10 charge of F. F. G. powder, or a 10/10, or unit, charge of F. G. powder. At these velocities the rifle was fairly accurate. For velocities very much greater than 2,000 feet per second, the accuracy was impaired.

These curves do not pass through the origin, or zero. Nor should we expect them to do so, since a certain quantity of every powder charge is required simply to start the ball and push it up to the muzzle. With this in mind and, of course, taking cognizance of the probability that this quantity is not the same for low velocities as for very high ones, the following test was made. Very small charges of powder were weighed and loaded as usual. The distance up the barrel which each charge moved the ball was noted by inserting the ram-rod and noting the displacement. In this way the data for the curve shown in Fig. 4 were obtained. From this curve it was found that a charge of

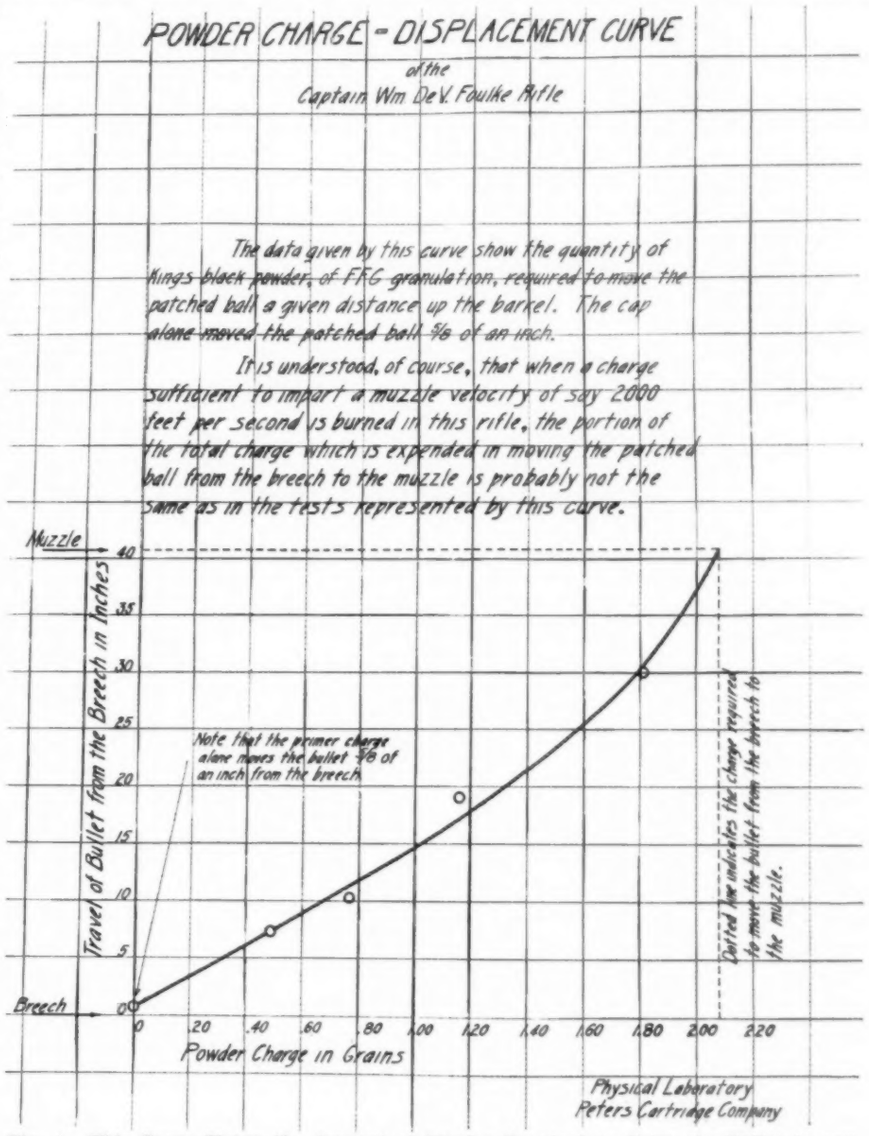
POWDER CHARGE - DISPLACEMENT CURVE
of the
Captain Wm DeV. Foulke Rifle
The data given by this curve show the quantity of Kings black powder, of FFG granulation, required to move the patched ball a given distance up the barrel. The cap alone moved the patched ball 5/8 of an inch.
It is understood, of course, that when a charge sufficient to impart a muzzle velocity of say 2000 feet per second is burned in this rifle, the portion of the total charge which is expended in moving the patched ball from the breech to the muzzle is probably not the same as in the tests represented by this curve.
Muzzle
Breech
Travel of Bullet from the Breech in Inches
40
35
30
25
20
15
10
5
0
Note that the primer charge alone moves the bullet 5/8 of an inch from the breech.
Dotted line indicates the charge required to move the bullet from the breech to the muzzle.
0
.20
.40
.60
.80
1.00
1.20
1.40
1.60
1.80
2.00
2.20
Powder Charge in Grains
Physical Laboratory
Peters Cartridge Company

Fig. 4. This Curve Shows the Amount of Powder Required to Drive the Bullet to any Point Between the Breech and Muzzle of the Capt. Foulke Rifle.

It is of course realized that the amount of powder required to drive the bullet from the breech to the muzzle is not the same with large as it is with the very small charges. However, the curve referred to shows an interesting relation between ball and powder charge while in the barrel.

2.08 grains was just sufficient, on the average, to drive the ball out of the muzzle. The cap alone moved the ball only 5/8 of an inch.

CAPT. JOHN G. W. DILLIN, in his "Kentucky Rifle," published in 1926, mentions the following test made at Frankford Arsenal on December 23, 1921. A caliber .38 flint-lock rifle, having a 36-inch barrel, using a 78-grain bullet, was loaded with a charge of 36 grains of black powder, presumably F. F. G., which gave an instrumental velocity of 1,468 feet per second over the first 52 feet from

Fig. 5. The Caliber .58 Springfield Rifle, Model of 1861. This rifle was the principal arm of the infantry throughout the Civil War. Fig. 6. The Caliber .58 Remington Rifle, Model of 1863. This arm was frequently carried by the Zouave regiments of the Civil War. Fig. 7. Colt's Military Model, Patent of 1857, 5-shot, Revolving Rifle, Number 8282, Caliber .56, Pugsley Collection. Fig. 8. Colt's Military Model, 6-Shot, Revolving Rifle, Number 117, Caliber .44, Pugsley Collection. Fig. 9. Colt's Sporting Model, 6-Shot, Revolving Rifle, Number 1379 Caliber .36. A perfect specimen from the Pugsley Collection. Fig. 10. Colt's Target Model, Patent of 1856, 6-shot, Revolving Rifle, Number 273, Caliber .36, Pugsley Collection.

the muzzle. In this connection Captain Dillin wrote, at the time, "It is believed that the velocity could be brought to nearly 2,000 feet, but the charge used in these tests would have been called a 'full-load' in pioneer days."

Captain Dillin's remarks on the subject are amply verified by our tests. It will be noted that the velocity of 1,468 feet per second obtained with a 36-grain charge of F. F. G. powder and a 78-grain bullet in Captain Dillin's rifle is in substantial agreement with those published in this paper, a 36-grain charge of F. F. G. powder in Captain Foulke's rifle of the same caliber giving a velocity of 1,600 feet per second over the first 20 feet of its range, and although Captain Dillin's rifle used a somewhat lighter ball, the barrel of his rifle was shorter and presumably did not burn the powder charge quite as efficiently as the longer one. It is true that one of these arms was a flint and the other a percussion lock rifle and presumably the breech pressure of the former would be somewhat more reduced by leakage at the vent than in the latter case. However, this does not appreciably alter the case in point.

The question of the change in the velocity for a given change in the powder charge is one which has interested

shooters since the advent of the sporting rifle two or three hundred years ago. In an excellent book on "The Sporting Rifle and Its Projectiles," by Lieut. James Forsyth, published in London in 1863, the author states: "It used to be a prevalent idea, that, by increasing the powder charge, no increase in velocity or power was obtained. It is true that every increase of powder does not give a proportionate increase in velocity, but up to the extent the barrel will burn, it will increase the velocity. Ordinarily barrels will burn a great deal more powder than it is ever advisable to use; and, practically speaking, there is no additional charge which will not give additional power. The true state of the case seems to be, that by increasing the charge of powder, you increase the velocity in the proportion of the square roots of the charges. But the penetrations into ordinary substances are as the squares of the velocities; you therefore, obtain increased penetrations in proportion to the charge you use."

When one considers the status of the subject of gunnery as a whole at the period in which these lines were written the above cannot but be considered as most excellent. Indeed for moderate charges, with the average muzzle-loading sporting rifle, the above criterion of velocity is quite correct. Consider, for instance, the "Velocity-Powder Charge Curve" for F. F. G., black powder as shown in Fig. 3. If we take the velocity, as obtained with this rifle and ball combination, as equal to 850 feet per second for a 10-grain charge and compute the velocity by means of Lieutenant Forsyth's rule for charges of 20, 30, 40 and 50 grains of powder the computed curve will be found to be nearly coincident with the actual curve over this range, departing slightly beyond the 40-grain charge.

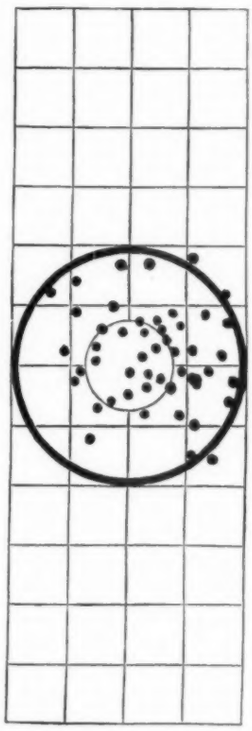

Fig. 11. This target is reproduced from "Cleveland's Hints to Riflemen" published in 1864. "The annexed representation of a target shot by Lieut. Hans Busk, of the Victoria Rifles at 400 yards, with Colt's rifle, affords convincing evidence of its accuracy. . . ."

As might be expected, the above rule is merely an approximation, though in this case an exceedingly close one, and does not hold at velocities much above 1,800 feet per second, since the air resistance, which the projectile encounters above this range, increases more rapidly than the energy derived from the corresponding increment of the powder charge. Thus the actual curve falls below the computed curve at velocities higher than 1,800 feet per second.

Also, of course, although the energy, and therefore the ability to do work, may be doubled, it does not follow that twice the powder charge will give twice the penetration, since with higher velocities the bullet is differently resisted and deformed accordingly, thus dissipating its energy over a larger area and reducing its penetration. Much depends upon the nature of the target; 10 inches of pine boards, each one inch apart, offering a vastly different resistance than the same thicknesses of material without the spaces in between. In the former case there is room between the boards to allow the splinters and material splintered and punched out by the bullet to move clear of its path. While in the latter case the bullet after penetrating a short distance must, in the case of the flat nose bullets or round balls, push a large mass of mushroomed material ahead of it and thus add to its resistance enormously.

A List of the Different Patterns and Prices of Rifles and Carbines, Manufactured by

Colt's Patent Fire Arms Manufacturing Co.

HARTFORD, CONNECTICUT.

RIFLES.

New Model Steel Mountings, Six Shots, Caliber or Size of Bore, 36-100ths of an inch diameter (carrying 42 Elongated or 86 Round Bullets to the pound):

Twenty-four inch-Barrel, ...	Weight 9 lbs.,	$32.50
Twenty-seven inch-Barrel, ...	" 10 lbs.,	35.50
Thirty-inch-Barrel, ...	Weight 10 lbs. 8 oz.,	38.50

Same Style, Six Shots, Caliber or Size of Bore, 44-100ths of an inch diameter (carrying 28 Elongated or 48 Round Bullets to the pound):

Twenty-four inch-Barrel, ...	Weight 8 lbs. 15 oz.,	35.00
Twenty-seven inch-Barrel, ...	" 9 lbs. 2 oz.,	38.00
Thirty-one and 5-16 inch-Barrel, . .	" 9 lbs. 10 oz.,	41.00

Same Style, Five Shots, Caliber or Size of Bore, 56-100ths of an inch diameter (carrying 14 Elongated or 24 Round Bullets to the pound):

Twenty-four inch-Barrel, ...	Weight 8 lbs. 14 oz.,	37.50
Twenty-seven inch-Barrel, ...	" 9 lbs. 11 oz.,	40.50
Thirty-one and 5-16 inch-Barrel (Pattern used by the U. S. Army),	Weight 9 lbs. 15 oz.,	43.50

CARBINES.

New Model, Steel Mountings, Rifled Barrels, 18 or 21 inches long;

Six Shots, Caliber or Size of Bore, 36-100ths of an inch diameter (carrying 42 Elongated or 86 Round Bullets to the pound);	Weight 8 lbs. 8 oz.,	30.00
Six Shots, Caliber or Size of Bore, 44-100ths of an inch diameter (carrying 28 Elongated or 48 Round Bullets to the pound);	Weight 8 lbs. 12 oz.,	32.50
Five Shots, Caliber or Size of Bore, 56-100ths of an inch diameter (carrying 14 Elongated or 24 Round Bullets to the pound);	Weight 9 lbs. 8 oz.,	35.00

Fig. 12. Advertisement of Colt's Rifles and Carbines which Appeared in the Back of "Cleveland's Hints to Riflemen," published in 1864.

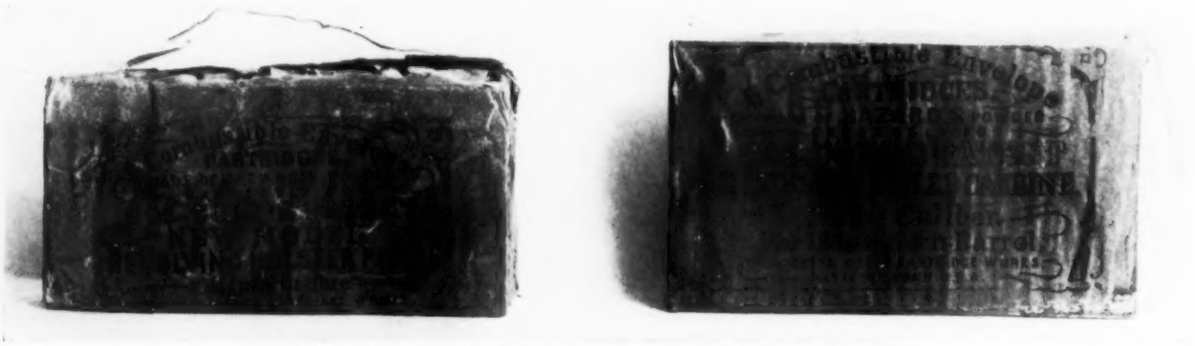

Fig. 13. Two packages of the Original Colt Combustible Cartridges.

Each package contains "6 Combustible Envelope Cartridges Made of Hazard's Powder," one for the caliber .44 Revolving Rifled Carbine with 12- to 18-inch barrel and one for the caliber .44 New Model Revolving Holster Pistol. (Obtained through the courtesy of Mr. Edwin Pugsley.)

U. S. Rifled Musket, Model 1861.—This arm (Fig. 5) is of particular interest in that it was the principal arm of the infantry throughout the Civil War.

The standard barrel length was 40 inches. The twist was right hand, three grooves, uniform, and one turn in 72 inches. The rifling was the same as that used in the Model 1855 rifle with 33-inch heavy barrel. It was also the same as the 1855 musket with 40-inch barrel, viz., 0.015-inch deep at the breech, gradually decreasing in depth to 0.005-inch at the muzzle.

Bannerman says, in part, concerning this arm, "The U. S. fabricated 801,997 and purchased 670,617 of these during the years '61, '62, '63 and '64. Many firms accepted contracts for these and had to build a factory to make them in. It was late in 1862 before deliveries from contractors began in satisfactory quantities.

"After the battle of Gettysburg, 27,574 muskets were sent to Washington Arsenal. Of these 24,000 were loaded, 6,000 with one load each, 12,000 with two loads each, 6,000 had three to ten loads each, and one had 23 loads."

The regulation caliber .58 paper cartridge measured about 2 inches in length. Assuming such cartridges to load into a length of $1\frac{3}{4}$ inches, 23 such charges would slightly more than fill the 40-inch barrel from breech to muzzle.

To the 18,000 muskets known to have been loaded with more than one charge no doubt at least as many more must be added to account for those similarly charged by troops fortunate enough to carry them off the field. However, even when the total number of overcharged muskets is considered, the percentage, based on the total number of both armies engaged, is not very great for the three days' fighting in and around Gettysburg which culminated in the heroic charge of the fifteen Gray brigades.

The standard load for the cal. .58 Springfield was 60 grains of musket powder and a 500-grain, hollow base, conical, 3-groove bullet as determined by the U. S. Ordnance Board of 1855 after an exhaustive series of tests, running intermittently as far back as 1841 and from 1849 with conical cavities.

With regard to the Minie bullet, it is of interest to pause for a moment to refer to one of the many fantastic ideas prevalent at that period, and even at the present time, as to these and other bullets.

Lieut. Hans Busk in his book "The Rifle and How to Use It" (London, 1858) in referring to the wooden plug used in the base of some types of the Minie ball writes that it "no doubt prevents any collapsing of the sides of the bullet when leaving the barrel, a circumstance which would otherwise happen, and thus disfigure its shape, and act prejudicially in other respects."

One fact which the average so-called "practical shooter" never considers in regard to such a phenomenon is that the maximum pressure which could ever be exerted on the side of the bullet due to a perfect vacuum at the base would be approximately 15 pounds per square inch, the atmospheric pressure, or slightly more than two-tenths of a pound for every eighth inch square surface of area. It should be obvious to the most inexperienced rifleman that such a force would be utterly inadequate to crush in the sides of any bullet capable of standing the shock of firing.

It is of course quite possible for the air pressure in front of the bullet to attain very considerably greater magnitudes than that of atmospheric pressure, but such a force would have no component tending to cause the sides to collapse. Its effect in fact would be quite the opposite.

Many of the early writers considered that the bullet moved out of the barrel with a high vacuum behind it and some even advocated boring holes in the breech of early percussion guns to relieve this supposed vacuum, which otherwise they feared would cause the barrel to collapse.

One wonders at the nature of the miraculous force which these worthies supposed it was that pushed the bullet out of the barrel. Even had their supposition been correct, it would be quite impossible in the time available[2] to introduce even one cubic inch of air at atmospheric pressure into the barrel even if the vent which they provided had been considerably greater in diameter than any that were ever used.

Yet these old ideas die hard, for not long ago a visitor in our laboratory, upon looking at one of our spark photographs showing a charge of shot at a distance of 18 inches from the muzzle with the felt wads still in contact with the lead pellets, remarked, "Why, the choke does not hold the wads back, does it?" Certainly not, and considering that they are being urged to move out of the muzzle by a force of hundreds of pounds, this surprising fact seems to be explainable.

With the musket of 1855 the velocity as determined in an Army test on November 15, 1855, by the use of the ballistic pendulum, using 60 grains of powder and a 500-grain bullet, was 963 ft./sec. The 1855 musket had a 40-inch barrel.

2. Even with the black powder charges of the muzzle-loading period, fired with percussion caps, the total time elapsing from the instant in which the hammer strikes the cap until the bullet leaves the muzzle of the rifle or musket is approximately twelve thousandths of a second.

Fig. 14. Greene's Oval Bored, Breech-Loading, Bolt-Action, Percussion Rifle. Patent of Nov. 17, 1857.

TABLE II
U. S. Rifled Musket, Model 1861
Caliber .58 M. L.

Shot in Number	Velocity in Feet per Second	Remarks
1	896	Three original Civil War paper cartridges supplied by courtesy of Francis Bannerman Sons Co.; 477-grain bullet and 60 grains of black powder, approximately Fg. granulation.
2	843	
3	997	
Avg.	912	
4	908	
5	903	
6	909	Nominal 500-grain Minie bullet (494 to 498 grains) and 60 grains du Pont Fg. black powder. Wadding of approximately the same size and consistency as that of the Civil War paper cartridge, one over the powder and one over the bullet.
7	922	
8	952	
9	916	
10	925	
11	926	The average of 923 feet per second represents very closely, in all probability, the velocity of the standard cartridge of the rifled infantry musket of the Civil War.
12	953	
13	918	
Avg.	923	
14	877	
15	908	
16	851	564-grain Enfield, or Pritchett, bullet and 60 grains of du Pont Fg. black powder.
17	905	
18	816	
Avg.	871	

Through the courtesy of Francis Bannerman Sons Co. we secured a few of the Civil War paper cartridges as issued to the troops of that period. These contained 60 grains of powder of approximately F. G. granulation and a 477-grain, 3-groove Minie pattern bullet measuring 0.562-inch in diameter. As Mr. Walter E. Heightshoe has suggested, it is probable that considerable latitude was permitted contractors in the matter of bullet weights.

As determined with our precision oscillograph equipment the average velocity of these cartridges, three-quarters of a century after their manufacture, was 912 feet per second, as shown in Table II.

Using cast Minie bullets (the Civil War bullets are said by some to have been swaged) of nominal 500 grains weight (494 to 498) and a powder charge of du Pont Fg. black powder, an average velocity of 923 feet per second was obtained. This figure represents in all probability the velocity of the bullet of the standard infantry rifle of the Civil War. Wadding[3] of the same size and consistency as that of the Civil War paper cartridge was used throughout these tests, one wad over the powder and one over the bullet.

Using the so-called Pritchett or Enfield ball weighing 564 grains, without grooves, but having a rounded point and conical base cavity, together with a charge of 60 grains of du Pont, Fg. black powder, the average velocity was 871 feet per second.

CALIBER .58 REMINGTON, MODEL OF 1863.—The Remington Model 1863 rifle (Fig. 6) with brass mountings was supposed to be a copy of the 1855 without the Maynard Primer Lock. It had, however, a different system of rifling, viz., seven narrow, shallow grooves with a pitch of one turn in 60 inches instead of one in 72. The barrel is 33 inches long. This arm has a fine, polished, walnut stock and is of excellent workmanship throughout.

TABLE III
Remington Rifle, Model 1863
Caliber .58 M. L.

Shot in Number	Velocity in Feet per Second	Remarks
1	827	
2	898	
3	867	
4	925	Nominal 500-grain Minie bullet (494 to 498 grains) and 60 grains du Pont Fg. black powder. Wadding of approximately same size and consistency as that of Civil War paper cartridge, one over the powder and one over the bullet.
5	932	
6	935	
7	890	
8	959	
9	951	
10	949	
Avg.	913	
11	835	
12	826	564-grain Enfield, or Pritchett, bullet and 60 grains du Pont Fg. black powder.
13	844	
14	837	
Avg.	835	

It is said that in civilian use after the war a charge of 75 grains of powder was preferred. This is probably quite true, as this splendidly made arm could handle it easily.

Using the standard Civil War cartridge components, 500-grain Minie bullet and 60 grains of du Pont Fg. black powder, the average velocity for this rifle was 913 feet per second. See Table III.

In these, as in all the tests described in this paper, the bore was carefully cleaned after each shot.

COLT'S MILITARY MODEL, Patent of 1857, 5-Shot, Revolving Rifle, Number

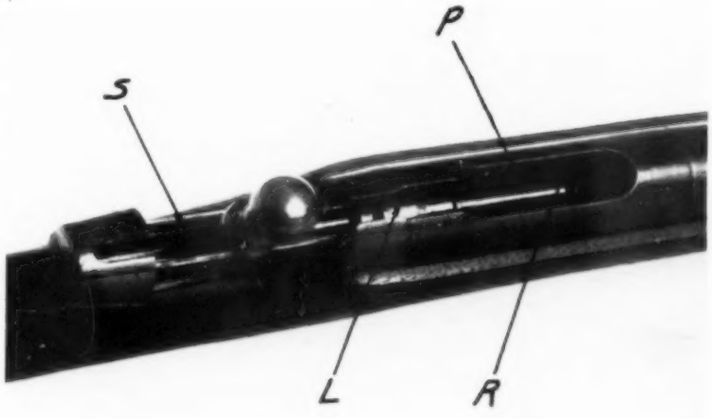

Fig. 15. Breech Mechanism of the Greene Oval Bored, Breech-Loading, Bolt-Action, Percussion Rifle. (Pugsley Collection).

3. Judging from the various methods stated by old soldiers to have been used in loading the Civil War rifled musket, considerable latitude in the matter seems to have existed. Some stated that all wadding was discarded and the bullet loaded bare on the powder charge. Others state that the bullet was sometimes loaded in its paper envelope. This latter method appears to be impossible with standard bullets but may have been possible with bullets considerably under the proper caliber.

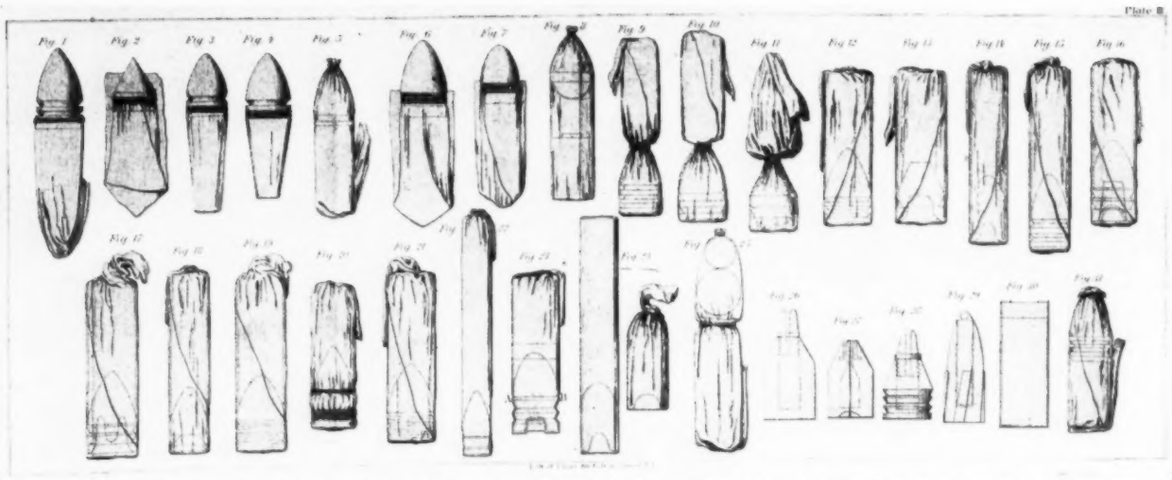

Fig. 16. The Cartridges of this Illustration are Reproduced from "Rifles and Rifle Practice," published in 1859 by Lieut. C. M. Wilcox.

8282. Caliber as measured at cylinder chambers .575-inch, nominal caliber .56-inch.

Colt's caliber .56 Military Model Patent of 1857 (see Fig. 7), 5-shot revolving rifle, number 8282, caliber as measured at the cylinder chambers .575-inch, length of barrel 37½ inches, 7 grooves, right hand gain twist. The rear sight, the windage zero of which is adjustable, has one fixed vertical leaf for 100 yards and two folding leaves for the 300 and 600-yard ranges.

The charge used in this test was the service one consisting of 60 grains of Fg. black powder and a 500-grain Minie ball. The results of this test are given in Table IV.

TABLE IV
Colt Caliber .56 Military Model, Revolving Rifle

Shot Number	Velocity in Feet per Second	Remarks
1	847	
2	849	The bullet used was of nominal 500 grains weight (494 to 498). It was loaded without a patch into the cylinder chambers, in which it fitted tightly. The charge was 60 grains of du Pont Fg. black.
3	831	
4	845	
5	806	The grooves of the bullet were filled with tallow.
Avg.	836	

Note: One of the original Colt caliber .56 molds was not available at the time of the above tests. Hence caliber .58 Minie balls were slightly rolled between iron plates until of such a diameter as to load properly into the chambers without a patch. The original caliber .56 conical ball weighed 515 grains.

Incidentally, the above data, in conjunction with that of Table II, provide some very interesting information as to the loss of energy occasioned by the space between the cylinder and the barrel. Of course the data here given are only applicable, strictly speaking, to arms using the same ammunition and having relatively long barrels but they probably furnish a rough approximation for similar conditions in revolvers as well. With the cal. .58 U. S. rifled musket Model of 1861 the average velocity obtained for a 500-grain Minie ball and 60 grains of Fg. black powder was 923 feet per second. The Colt cal. .56 5-shot revolving rifle has almost precisely the same total barrel length but with, of course, the additional feature of the leakage space at the junction of the cylinder and barrel. Using the same charge in the Colt rifle as that of the "61" rifle, namely, a 500-grain Minie ball and 60 grains of Fg. black powder, a muzzle velocity of 836 feet per second was obtained. Hence it may be shown that approximately 17.5 per cent of the total available energy was lost in this case due to the cylinder joint.

Incidentally the space between the cylinder and barrel for the caliber .56 Colt rifle was approximately .023-inch, so that it seems quite safe to say that in present day arms not more than 17 per cent of the energy is likely to be dissipated in this manner since the average space at the junction of the cylinder and barrel in revolvers of today is much smaller than the .023-inch considered in this case. This clearance for the average caliber .38 revolver is not far from 0.10-inch.

COLT'S MILITARY MODEL, 6-Shot Revolving Rifle, Number 117. Caliber as measured at cylinder chambers .452-inch, nominal caliber .44-inch.

Colt's Caliber .44 Military Model (Fig. 8), 6-shot revolving rifle, number 117, caliber .452 inches as measured at cylinder chambers, length of barrel 31-5/16 inches, 7 grooves, right hand gain twist, sights adjustable for windage zero and leaves for the 100-, 300- and 600-yard ranges.

This rifle was loaded with 40 grains of du Pont Fg. black powder and a round ball .460-inch in diameter weighing 147 grains. The ball was loaded without a patch into the cylinder chambers in which it fitted tightly.

Fig. 17. U. S. Harpers Ferry, Flint Lock Rifle, Model of 1800.
This specimen from the Pugsley Collection is dated 1803 and is described in the text.

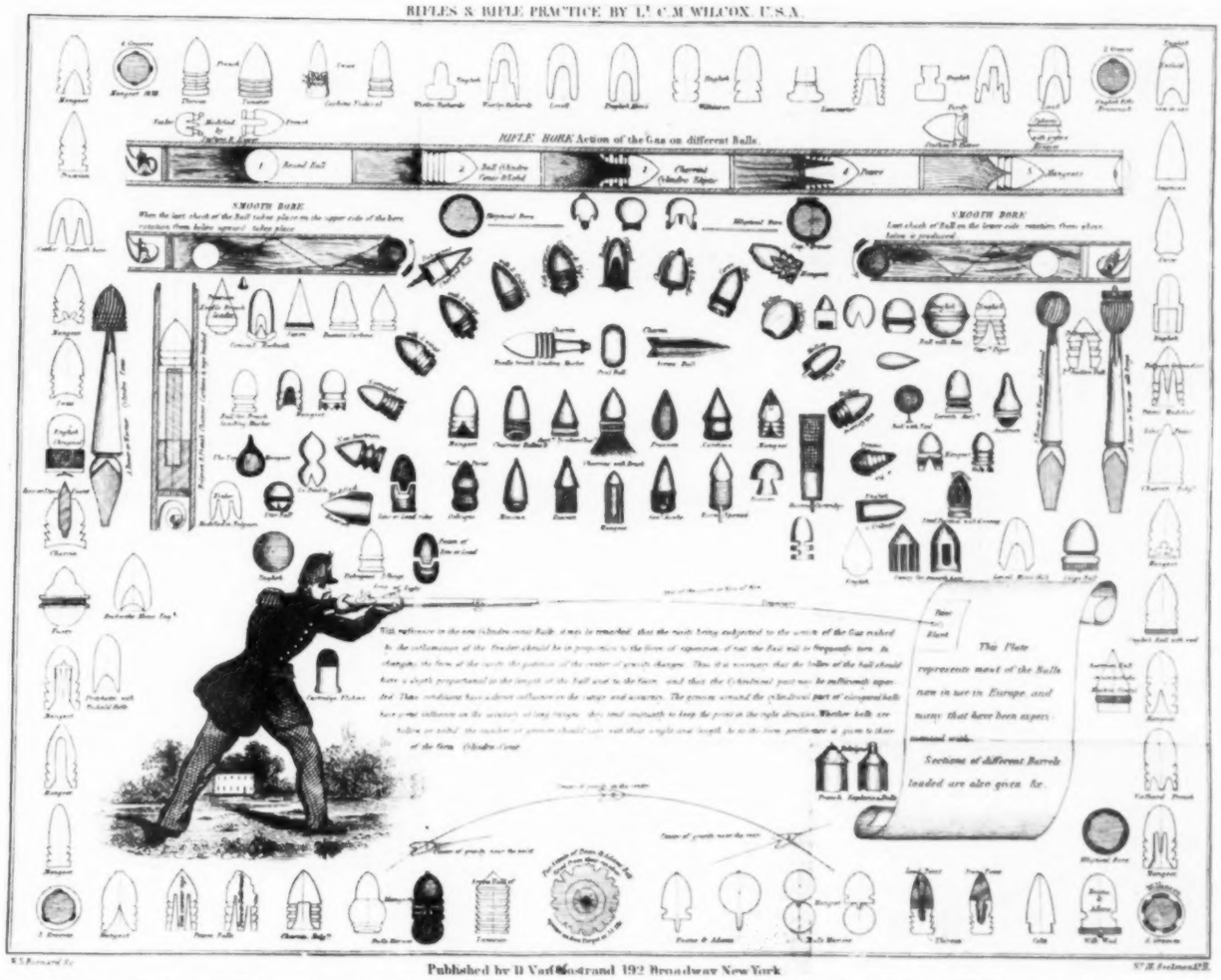
RIFLES & RIFLE PRACTICE BY Lt C.M. WILCOX, U.S.A.
RIFLE BORE Action of the Gas on different Balls.
SMOOTH BORE
SMOOTH BORE
This Plate represents most of the Balls now in use in Europe and many that have been experimented with.
Sections of different Barrels loaded are also given for.
Published by D Van Nostrand 192 Broadway New York

Fig. 18. The Various Bullets and Other Illustrations of this Interesting Plate are Reproduced from "Rifles and Rifle Practice," Published in 1859 by Lieut. C. M. Wilcox.

The results of the tests with this rifle are shown in Table V.

TABLE V
Colt's Military Model, Caliber .44, 6-Shot, Revolving Rifle

Shot Number	Velocity in Feet per Second	Remarks
1	1180	
2	1158	The charge for this rifle consisted of 40 grains of Fg. du Pont, black powder and a round ball weighing 147 grains which was loaded without a patch into the cylinder chambers, in which it fitted tightly.
3	1215	
4	1156	
5	1260	
Avg.	1194	

COLT'S SPORTING MODEL, 6-Shot Revolving Rifle, Number 1379. Caliber as measured at cylinder chambers .375-inch, nominal caliber .36-inch.

Colt's Caliber .36 Sporting Model (Fig. 9), 6-shot revolving rifle, number 1379, caliber .375 inches as measured at cylinder chambers, length of barrel 27 inches, 7 grooves, right hand gain twist.

This is the finest Colt rifle we have ever seen. The wrist is finely checkered and the arm is of a beautiful finish throughout.

TABLE VI
Colt's Sporting Model, Caliber .36, 5-Shot Revolving Rifle

Shot Number	Velocity in Feet per Second	Remarks
1	1340	
2	1278	The charge consisted of 30 grains of du Pont FFg. black powder and a round ball weighing 84.5 grains. The ball was loaded without a patch into the cylinder chambers, in which it fitted tightly.
3	1430	
4	1530	
5	1489	
Avg.	1413	

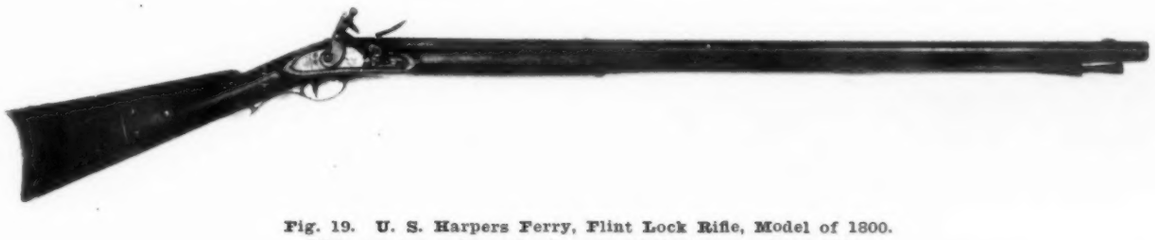

Fig. 19. U. S. Harpers Ferry, Flint Lock Rifle, Model of 1800.
This specimen, from the Pugsley Collection, is dated 1818.

Colt's Target Model, Patent of 1856, 6-Shot, Revolving Rifle, Number 273, Caliber .36.

Colt's Target Model, Patent of 1856 (Fig. 10), 6-shot, revolving rifle, number 273, caliber .382-inch as measured at cylinder chambers, length of barrel 30 inches, 7 grooves, right hand gain twist. This rifle is not in shooting order but it is reproduced here for the sake of the interest which attaches to its rather unique design.

Some idea of the esteem in which the Colt arms were held by those who used them most may be had from the following quotation from Capt. R. B. Marcy's "Hand-Book for Overland Expeditions."

"For my own part I look upon Colt's rifle as a most excellent arm for border service. It is the most reliable and certain weapon to fire that I have ever used * * *."

Cleveland in his "Hints to Riflemen" reproduces a target fired by Lieut. Hans Busk of the Victoria Rifles with a Colt rifle at a range of 400 yards (Fig. 11). It will be noted that all of the shots struck well within a square of two feet on a side.

The advertisement (Fig. 12) of the Colt Co. taken from the back of Cleveland's "Hints to Riflemen" is of considerable interest in the information it affords of the Colt rifles considered in this article.

Two packages of the original Colt combustible cartridges obtained through the courtesy of Mr. Edwin Pugsley are shown in Fig. 13. Each package contains "6 combustible envelope cartridges made of Hazard's powder," one for the caliber .44 Revolving Rifled Carbine with 12- to 18-inch barrel and one for the caliber .44 New Model Revolving Holster Pistol.

Greene's Oval Bored, Breech-Loading, Bolt-Action Percussion Rifle.

Greene's oval bored, breech-loading, bolt-action percussion rifle (Fig. 14), caliber .545-inches, length of barrel 36 inches, marked "Greene's Patent Nov. 17, 1857."

This rifle does not, perhaps, come within the scope of this paper if judged strictly by the title. Yet it was a contemporary of the muzzle-loading era and as such one of the most interesting. It is therefore included here because of its unique construction and the unusual interest which attaches to it.

Referring to Fig. 14, a small button "B" must be pressed before the bolt can be raised. When the bolt is unlocked it may be rotated upward through 90 degrees and drawn to the rear precisely as with the modern Springfield.

In loading, a bullet was first placed in the breech and then, by means of sliding the bolt handle to its farthest forward position, the plunger "P" (Fig. 15) seated the bullet into the chamber. The bolt handle was then withdrawn to its most rearward position carrying the sleeve "S" with it and the paper cartridge containing a bullet at its base was then inserted in the breech.

With regard to these cartridges Cleveland says in his "Hints to Riflemen," "The cartridge has the bullet in its base, with a greased wad between it and the powder, which, with the bullet, packs the joint perfectly at every discharge, and prevents the slightest escape of gas."

After the insertion of the cartridge the bolt with its sleeve "S" was then carried forward seating the cartridge in the chamber, the cartridge bullet acting as the breech block for the charge. The bolt handle is then turned down through 90 degrees thus engaging the locking lugs "L" in the cam recesses "R" one of each of which is shown in Fig. 15. After the charge had been fired the bolt was unlocked by pressing with the thumb on the button "B" (Fig. 14) and simultaneously turning the bolt handle up and to the left through 90 degrees but instead of first drawing the bolt to the rear it was pushed forward until the bullet which acted as the breech block for the first charge had been seated in the chamber by the plunger "P" in readiness for the next shot when the loading operation was repeated.

The ignition was by means of the regulation musket cap; the hammer, which was of the ring type, being located underneath the barrel.

Sawyer says the charge was "68 grains of powder," presumably Fg., and "a Minie bullet weighing 1¼ ounces," which would mean approximately 550 grains.

The butt trap contained a bristle brush which was threaded for the small end of the ramrod and this arrangement with a little water provided an ideal method of readily removing the black powder fouling. The rear sight was graduated in steps of 100 yds. up to 800 yds. The barrel is fastened with bands retained by band springs. This arm was a splendidly made and very rugged military rifle.

In the actual firing tests of this rifle none of the original cartridges or bullets was obtainable. Hence a 564-grain Pritchett ball having a Minie pattern base was turned down in a lathe to a diameter of .540-inch. Each of these turned bullets weighed 530 grains or 20 grains less than that reputed to have been the standard weight for this rifle.

In loading, the first ball was inserted and then the powder charge of 68 grains of du Pont Fg. black powder was introduced into the chamber by means of a glass funnel in order to avoid having some of the powder lodge in the breech recesses. After the introduction of the powder the second bullet was inserted and since no cartridge paper was available a small wad was added to fill up the remainder of the space between the rear of the "breech block bullet" and the face of the bolt. Actually the same bullet was used behind the powder charge in the breech for each shot since a bullet when used in this way is somewhat deformed by gas pressure, etc., and hence a new bullet was seated in the bore for each shot. As usual throughout these tests the bore of the rifle was carefully cleaned after each shot.

The results of the velocity tests of the Greene rifle are shown in Table VII.

TABLE VII

Shot in Number	Velocity in Feet per Second	Remarks
1	987	
2	957	The charge used in this test consisted of 68 grains of du Pont Fg. black powder and a modified Pritchett ball weighing 530 grains and having a Minie pattern base. The bore was carefully cleaned after each shot.
3	958	
4	975	
5	975	
Avg	970	

The principal objection to this splendidly made arm seems to be that after a few shots the fouling of the bolt renders it a difficult matter to load the arm in the usual manner. However, it is quite probable that this defect was greatly reduced with the original cartridges which as previously stated contained a gas check wad behind the bullet which acted as the breech block for the charge. Also since this wad was lubricated it probably very materially reduced the tendency to fouling in the bore of the piece.

U. S. HARPERS FERRY RIFLE, CALIBER .54, MODEL 1800.—In Fig. 17 is shown a U. S. Flint Lock, Harpers Ferry Rifle, Caliber .54, Model of 1800. The barrel of this rifle is $32\frac{3}{4}$ inches long and has seven grooves which make slightly more than half a turn in the length of the barrel. The approximate pitch is one turn in 50 inches, right-hand twist. The lock plate is stamped "Harpers Ferry, 1803" and has the conventional spread-eagle approximately in the center of the lock plate. The butt plate, patch box, trigger guard and fore end cap are of brass.

This rifle is from the Pugsley collection and is the one mentioned in Sawyer's "Our Rifles." Sawyer says of the charge for this rifle, "The official charge for the Model 1800 rifle was 90 to 100 grains of fine rifle powder and a half ounce pure lead ball loaded with a greased patch of either linen or buckskin. The muzzle velocity was 2000 f. s."

However, the value alone of the splendid specimen shown in Fig. 17 would of itself forbid incurring the risk of breaking it which would in all probability result from firing the piece in this day with any such charge as that mentioned above. Such a charge would be almost certain to crack the stock at the wrist and otherwise damage the piece.

The components of the load actually used in the tests of the rifle shown in Fig. 17 of this paper consisted of 50 grains of Fg du Pont black powder, a greased felt wad and a lead ball weighing approximately 240 grains. The bore of this rifle, after much cleaning, was brought into fair condition. The vent was not very badly corroded.

The velocities obtained with this rifle over the first 20 feet of its range, firing the above charge, were as follows:

TABLE VIII
U. S. Harpers Ferry Rifle, Model 1800

Shot Number	Velocity
1	960
2	985
3	1027
4	1093
5	1024
Avg.	1018 ft. sec.

The increasing velocities noted from the first to the fourth shots are real and are probably due to the condition of the barrel and possibly somewhat to changes inadvertently made in the loading, etc. The barrel was carefully cleaned after each shot.

In Fig. 19 is shown a second Harpers Ferry Rifle dated 1818 on the lock plate. This arm, however, is now smooth bore and was not fired. The barrel is $35\frac{3}{4}$ inches long and the fittings practically the same as those of the rifle shown in Fig. 17.

IT has been possible to gather together for these tests a set of practically new percussion rifles in almost perfect condition in so far as the bores, locks, etc., are concerned and it is felt that the velocity tests of the percussion arms listed in this paper are probably the most accurate yet obtained. This is in part due to the condition of the arms which possibly may have been equalled before but has certainly not been surpassed. The most potent factor, however, in obtaining with accuracy the data presented in this paper is to be found in the special oscillograph equipment and precision timing device with which the velocities discussed were determined. It may be said with certainty that nothing even remotely approaching it ever existed throughout the entire period in which muzzle-loading arms were in use.

At the beginning of these tests, about two years ago, it was intended to include a group of flint-lock rifles, particularly the Kentucky, which would be as representative of the flint-lock era as the percussion rifles we have described were of that period. Unfortunately the author has not been able to obtain flint-lock rifles the bores of which were in sufficiently good condition to warrant the labor of attempting to obtain velocity measurements from them. It is obvious that little would be added to our knowledge of such arms were the velocities measured with old rusty bores so burned out at the breech that in loading the ball and patch fairly fall through the last foot or so of their travel towards the breech, without even touching the sides of the barrel.

If the velocities obtained with the Captain Foulke rifle, of this article, are slightly lowered to allow for some loss of pressure at the vent in case of a flint-lock rifle the velocities thus obtained would represent accurately those of a flint-lock rifle of equal caliber and in equally good condition.

In conclusion, the author desires to express his grateful appreciation of the help afforded him by Captain William de V. Foulke, of West Virginia, in furnishing the caliber .38 rifle and much invaluable information relative to the subjects considered in this paper. The author is especially indebted to Mr. Edwin Pugsley, of the Winchester Repeating Arms Co., for the use of most of the rifles shown in this paper, and to Mr. Heightshoe of Columbus, Ohio, and Mr. Walter Cline, of Chattanooga, for their helpful suggestions and criticisms. The author's thanks are also due to Messrs. C. T. Ervin and M. F. Mathews of the Physical Laboratory of The Peters Cartridge Co. for their assistance in the routine measurements described in this paper.

New York Ordnance District Pistol Trophy

THE reserve officers of the New York Ordnance District, for the past several years, have been holding meetings each Monday night from September to April. At these meetings many matters pertaining to procurement, manufacture, storage, issue, materials, accounting and contracts have been under discussion.

As an evidence of the appreciation of the reserve officers for the splendid assistance of the regular officers both at the conferences and at the summer training camps at the Aberdeen Proving Ground, the New York Ordnance District has decided to present a pistol trophy in the form of a heavy silver loving cup to the Ordnance Department to be competed for by all reserve officers in attendance each year at the Aberdeen Proving Ground summer camp.

The trophy stands 20-inches high. On it is engraved the insignia of the New York Ordnance District and the following inscription: "Pistol Trophy, Aberdeen Proving Ground Ordnance Reserve Corps Camp." On the reverse side will be engraved each year the name of the winner of the regular record pistol shoot conducted during the camp. The trophy is to be retained at the Proving Ground as a permanent trophy, and formal presentation will be made at the opening of the camp which this summer will be conducted from July 27 to August 9th, inclusive.

Industrial Mobilization

Training Course for Reserve Officers of Supply Services

By Donald Armstrong*

SEVEN years have elapsed since the first group of reserve officers was ordered to duty in the Planning Branch of the Office of The Assistant Secretary of War "for the purpose of conferring with us regarding industrial mobilization." The character of these periods of active duty has altered with time and with the development and crystallization of ideas concerning the mobilization of industry. Every effort is made, however, not only to give the student reserve officer a sound conception of the proposed solutions of industrial mobilization problems, but to utilize the business experience of these officers in improving our own organization and methods.

During these years only forty-one Ordnance reserve officers have been on duty in the Office of The Assistant Secretary of War. As there are approximately fifteen hundred Ordnance reserve officers, it is clear the proportion trained here is too small. A greater number of these officers should apply for the fourteen-day training period in this office, and this would undoubtedly be the case if the nature of War Department procurement were clearly understood. The officers of the Supply Services must abandon a parochial point of view in considering procurement problems, and substitute the broader conception that is inculcated during a training period in the Office of The Assistant Secretary. What is meant by this broader point of view?

Nearly ten years ago Congress passed the amendment to the National Defense Act establishing the Office of The Assistant Secretary of War, thereby clearly separating the procurement functions from the military side of the War Department. Under The Assistant Secretary of War the Army Industrial College has the function of training the officers of the regular establishment in the procurement duties required to carry on a major war. The fifteen officers of the Planning Branch of his office are, in addition to their other duties, instructors in the Army Industrial College and are also charged with the training of reserve officers under the supervision of the Training Section of the office.

WHY, it may be asked, is the Office of The Assistant Secretary of War necessary? We are confronted by a condition, the outgrowth of over a hundred years' development and one well adapted to our Army's needs. That is to say, the Army is not served by one centralized purchasing agency but by seven Supply Services, each one of which is responsible for the procurement of certain types of matériel. The World War revealed a number of serious defects in this organization for procurement. Competition between the Supply Services in the same markets was one of the penalties for the lack of centralized control. A number of other fundamental weaknesses discovered then have been remedied by the organization of the Office of The Assistant Secretary of War.

The Assistant Secretary of War coördinates and controls the War Department supply program, thereby securing that unity and exclusiveness of purpose without which success is impossible. Coöordination means team work. It means a balanced system of procurement that will not allow one Supply Service to store up excessive supplies while others are suffering from lack of material or power, or labor, etc.

At the present moment we have the nucleus of the organization and the plans which will control and coördinate the decentralized operations of the Supply Services. But neither organization nor plans can possibly accomplish their purpose without a trained personnel to put them into effective operation. It is estimated that approximately one hundred and seventy officers will be needed in the Office of The Assistant Secretary of War in the event of a major war. Of this number only eight officers are of the Regular Army; the balance must be secured from other sources, more especially from the Organized Reserve. It is extremely important therefore that reserve officers assigned to this office be given as complete knowledge as possible of the functions they will have to perform. It is equally valuable that experienced officers of the various Supply Services, receive this same training so that they may realize that procurement of supplies is a problem of the War Department and not exclusively of the Supply Service to which they belong.

FOUR courses of training are given each year in the Office of The Assistant Secretary of War with from twelve to fifteen reserve officers assigned to each one. The purpose of these courses is to familiarize selected reserve officers with the organization and the methods of the organization in carrying out the statutory duties of the "supervision of the procurement of all military supplies * * * and the assurance of adequate provision for the mobilization of matériel and industrial organizations essential to war-time needs."

The training consists principally of a series of lectures by the various officers on duty in the Planning Branch, each of which is followed by a discussion of the methods adopted. Time is alloted for reading certain selected material in connection with the course.

The nature of the instruction can best be understood by enumerating the subjects covered in the lectures with brief comments on each.

1. "Industrial Mobilization. Orientation Talk."

By analyzing the defects of organization and methods in procuring supplies for the Army in 1917-18, the reasons are developed for the establishment of the Office of The Assistant Secretary of War. The present organization of the Army for procurement is contrasted with the former situation. The supervisory functions of the Office of The Assistant Secretary of War are described and a general review of procurement planning operations is provided so that the details of the particular functions will be under-

*Office of The Assistant Secretary of War. Major, Ordnance Department, U. S. Army.

stood in relation to each other in the subsequent lectures.

2. "Procurement Planning in a Supply Service."

Presumably, reserve officers assigned to this course have already received training in the procurement functions of their own branch. It is, nevertheless, considered desirable to preface a study of the supervisory functions of the Office of The Assistant Secretary of War by a general review of the industrial planning methods of a Supply Service. In this talk the decentralized operations of procurement are discussed.

3. "Specifications and Conservation in War."

While the determination of the type of article to be issued to troops is principally a military question and consequently under the War Department General Staff, the Office of The Assistant Secretary of War must have some control over this matter. Its extent is described in this discussion, which will include a study of the conservation measures where supplies are limited.

4. "Requirements and Statistical Records."

When a type of article has been adopted the next step is to find out how much is needed to meet a general mobilization plan. The computation of requirements is described in this talk. By what statistical devices can the operation of the Supply Services be controlled and coördinated in time of war? The proposed solution of this problem is presented.

5. "Allocations."

After the requirements of the various finished items have been computed, as described above, the Supply Services apportion or distribute the total load to the various War Department Procurement Districts. The districts then request the allocation of appropriate manufacturing plants for the use of a particular Supply Service. The methods of allocating plants are described in detail.

6. "Specific Procurement Plans."

These plans are written documents which show The Assistant Secretary of War that the Supply Service has apportioned its load as uniformly as possible throughout the country and that the requisite manufacturing plants have been allocated to meet the requirements. The utility of these plans, their form and substance, are described. Actual plans are distributed to the members of the class for study and criticism.

7. "Commodity Committees and Strategic Raw Materials."

Having reached a conclusion in the planning operations for the procurement of primary requirements, a study of the proposed methods for procuring the necessary raw materials and services needed in the manufacture of these articles is undertaken. The organization of the War Department Commodity Committees is described and a study is made of the proposed solution for procuring various strategic raw materials.

8. "Facilities."

The available facilities to meet the War Department load on industry will be far from sufficient. The role of The Assistant Secretary of War in controlling the construction of new facilities and the policies in reference thereto are described in this lecture.

9. "The Legal Phases of Industrial Mobilization and Price Control."

This includes a discussion of the important question of contracts between the Government and the manufacturing plants, and a brief discussion of the possibilities of price control by Governmental agencies.

10. "Power."

While power does not present as serious a problem in the matter of secondary requirements as do raw materials, labor and transportation, it is essential that the power problem be kept in mind. What this problem is and the proposed solution of it is described in this talk.

11. "Transportation."

Following a discussion of the transportation difficulties in 1917 and 1918, the present organization and the proposed methods to coördinate the various transportation systems of the country in the event of emergency are discussed.

12. "War Reserve."

It is estimated that mass production methods applied to munitions production will hardly be effective for a period exceeding at least one year after the beginning of mobilization. During that time the Army will fight with the supplies available on "M Day." The importance of war reserves to meet the deficit in early production is discussed in this lecture.

13. "Fiscal Section and Budget."

The matter of budgetary control is briefly discussed in this talk, so that there may be some familiarity with the method of preparing the budget under the present Governmental regulations.

14. "Labor."

In the production of the Army's requirements power is applied to raw materials to fabricate the finished item. The agency by which this is accomplished is labor. Just as air, water and food are all and equally necessary to sustain life, so raw materials, power and labor are all and equally necessary to produce finished items.

15. "Gauges in Mass Production."

This involves a brief non-technical description of the use of gauges in manufacturing and the examination of some actual gauges.

16. "The Army Industrial College."

This discussion of the industrial education of the Regular Army Officer shows to what extent the Regular Army is now emphasizing the industrial side of warfare.

THE course has proved its value in training some hundreds of reserve officers. In spite of the large amount of information to be absorbed in a period of fourteen days the instruction has apparently been successful, and there has been gratifying evidence from the student officers of the value of this training.

Certain limitations have to be imposed on applications from reserve officers for duty in the Office of The Assistant Secretary of War. Due to the small appropriation available, no application can be considered from officers residing at distances from Washington exceeding 1,000 miles. It is desirable to limit applications to officers of field grade, although in exceptional cases captains or lieutenants may be considered. All applications for duty must be submitted to the Office of the Chief of Ordnance through the proper district office.

The tentative dates for training in the next fiscal year are as follows: October 12-25, 1930; January 11-24, March 15-28, April 5-18, 1931.

Searchlights and Sound Locators

Part II: The 60-Inch Searchlight--Distant Electrical Control

By R. E. Gillmor and P. R. Bassett*

AS mentioned in Part I of this series of articles in the March-April issue of ARMY ORDNANCE where the high intensity arc was referred to, the brilliant vapor which forms the source of light in the Sperry searchlight is obtained from rare earths incorporated in the core of the positive carbon. To vaporize these materials and heat them

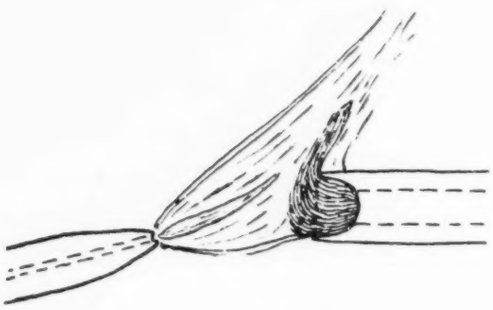

Fig. 1. The ball of vapor in the high intensity arc.
Derived from the rare earths cerium and lanthanum incorporated in the soft core of the positive. These earths are vaporized and projected into the crater by the stream of positive electricity (ions) emanating from the positive carbon. The vapor is held in the crater by the impingement of the stream of negative electricity (electrons) emanating from the negative carbon.

to incandescence it is necessary to employ a very high density of electric current in the positive carbon (Fig. 1). Because of this high current density the carbons would volatilize unless provision were made for keeping them at a safe temperature and preventing access of oxygen. In the Sperry lamp this is accomplished by conveying the current to the carbons at a point near their tips and by surrounding the current-carrying portion with disc-shaped radiating surfaces (Fig. 2).

To maintain a uniform hemispherical crater the positive carbon must be slowly rotated. This is accomplished by the feed mechanism which rotates the carbon at the same time that it feeds it. The positive feed has a minimum rate which is slightly less than the slowest rate of burning of the type of carbon employed. The thermostat control, to be described later, simply increases the rate of feed when the crater burns back out of focus.

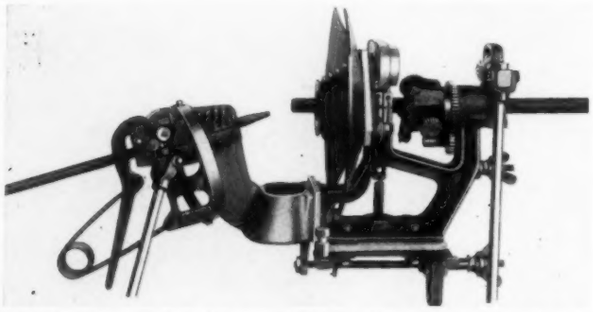

Fig. 2. To permit high current density without danger of volatilizing the carbon, the current-carrying portion of the positive is surrounded with a head which excludes oxygen and radiates the excess heat. To maintain a uniform hemispherical crater, the positive is slowly rotated by the same mechanism which feeds the carbon.

*Vice-President and Chief Engineer respectively, Sperry Gyroscope Company, Inc., Brooklyn, N. Y.

The carbon feeds are accomplished by means of knurled rollers which grip the carbon firmly between them. These rollers are driven by the feed rods which extend from the lamp heads to the lamp control mechanism mounted on the side of the searchlight drum.

A point which has been given special attention in the design of the lamp heads shown in Fig. 2 is convenience and speed in recarboning. Readily accessible levers provide instant release of both carbons so that with a hot lamp, recarboning can be accomplished within 30 seconds from the time the lamp switch is opened. The lamp control mechanism is mounted in a water-tight case on the side of the searchlight drum.

All feed movements are derived from a single reciprocating part driven by a small motor. In the case of the positive feed, a pawl carried by this reciprocating part is

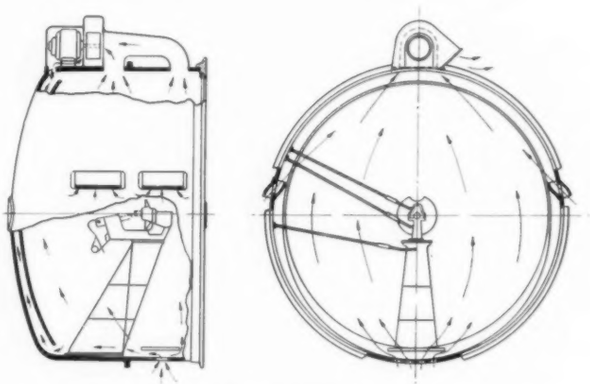

Fig. 3. The Ventilating System.
The purpose of the ventilating system is primarily to clean, not to cool. The nature of the high intensity arc is such that it must give off gasses. If these gasses are not withdrawn from the drum, they will deposit on the mirror and front door, thus decreasing the beam candle power below the value necessary for antiaircraft purposes.

set to engage one tooth at a time on the ratchet wheel which rotates the positive feed rod. The resulting rate of feed is slightly less than the rate of burning of the positive carbon. The positive crater will therefore gradually burn back out of focus. When it does so to the extent of 1/64th of an inch (.4-mm.), a pencil of light falls through a slit and impinges on a bimetallic strip. The resulting change of temperature of the bimetallic strip causes it to warp and close a circuit to an electro-magnet which draws a guard away from the positive feed pawl, thus allowing it to engage with more teeth of the ratchet at one stroke. The rate of positive feed is thereby increased and the positive crater is restored to focus before it can get out more than 1/32nd of an inch (.8-mm.).

To take care of any condition which may arise, provision

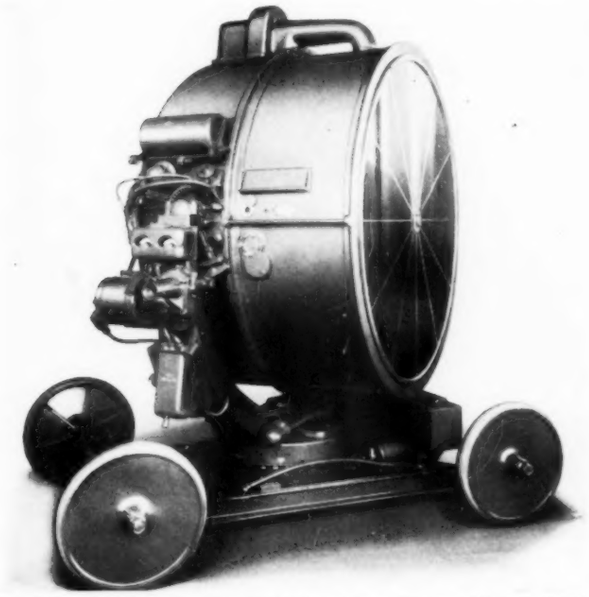

Fig. 4. All meters and controls of the Sperry 60-inch (152-cm.) searchlight are mounted on the right side of the drum.

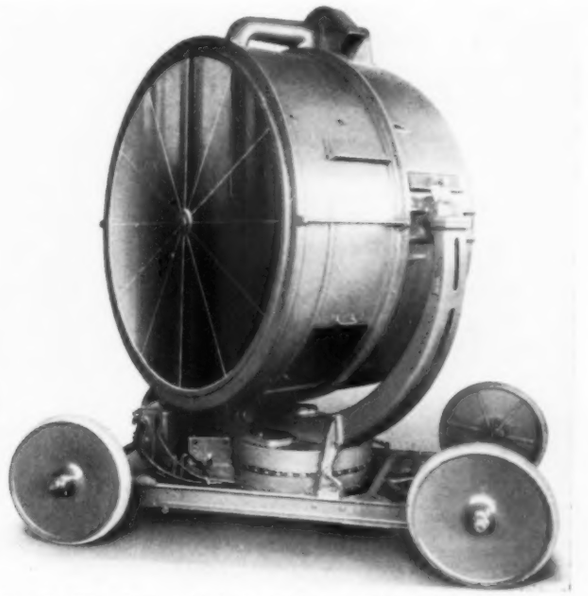

Fig. 6. The Sperry 60-inch (152-cm.) high intensity antiaircraft searchlight with the recarbcning door open.

is made for adjusting the rate of positive feed by hand. This is accomplished by a handle which governs the number of teeth engaged by the positive feed pawl at each stroke of the reciprocating part. The positive may also be directly controlled by hand through the medium of another handle.

The negative feed control is governed by an arc voltage coil. So long as the drop across the arc is normal, the negative feed pawls are held out of engagement with the ratchet wheel which rotates the negative feed rod. When the arc lengthens, the voltage across the coil rises, the coil attracts its armature, and the lower negative feed pawl is allowed to engage. The negative is thereby fed forward and the arc length is shortened to the proper value. If for any reason the arc length becomes too short, the upper pawl is allowed to engage and the negative carbon is drawn back. The arc length is controlled by a knurled head which varies the tension of a spring attached to the armature of the voltage regulating coil. A handle provides a means for feeding the negative carbon by hand. When hand feed is used, the feed pawls are held out of engagement by a button.

Striking of the arc is accomplished automatically by the negative feed mechanism. When striking the arc, the voltage coil receives full line voltage and the rate of feed is a maximum. The mechanism is so designed that this full rate will strike the arc quickly.

The operation of the ventilating system of the Sperry antiaircraft searchlight is illustrated diagrammatically in Fig. 3. Although the primary purpose of ventilation is to prevent deposit of light-absorbing films on the glass surfaces, it serves the secondary purpose of cooling the mirror. This secondary function is a precaution, not a necessity, and is simply a means of guarding against uneven heating of the mirror and consequent danger of breakage when the searchlight is used for long periods of time at high angles of elevation.

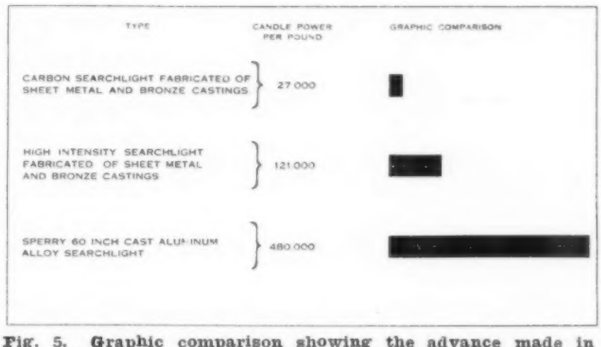
TYPE
CANDLE POWER PER POUND
GRAPHIC COMPARISON
CARBON SEARCHLIGHT FABRICATED OF SHEET METAL AND BRONZE CASTINGS
27,000
HIGH INTENSITY SEARCHLIGHT FABRICATED OF SHEET METAL AND BRONZE CASTINGS
121,000
SPERRY 60 INCH CAST ALUMINUM ALLOY SEARCHLIGHT
480,000

Fig. 5. Graphic comparison showing the advance made in beam candle power output per unit of weight.

THE complete antiaircraft searchlight is shown in Fig. 4.

The rear portion of the drum is cast in one piece from a corrosion-proof aluminum alloy. This method of construction gives great strength and rigidity with a minimum of weight. Its advantage over older forms of sheet metal construction is shown graphically in Fig. 5. It will be seen from this figure that the Sperry searchlight produces 480,000 beam candle power for each pound of weight.

An aluminum alloy especially developed for the purpose is used for trunnion arms, base and other parts requiring great strength and light weight. Repeated tests have amply proven that this type of construction will withstand the most severe shocks to which it can be subjected in service.

To provide perfect freedom of movement in azimuth, the trunnion arms are supported on a ball-bearing turntable. Current is conveyed to the searchlight through slip rings mounted on the stationary portion of this turntable. To provide freedom of movement in elevation, the horizontal trunnions of the searchlight are supported on heavy ball bearings in the trunnion arms. The suspension and balance of the drum are such that the searchlight can be moved about any axis by a light pressure of the finger.

It has been suggested that to provide greater ease in traversing an antiaircraft searchlight through the exact zenith, it should be provided with an additional axis of suspension. Experience has shown, however, that this is an unnecessary complication and in fact involves more

disadvantages than advantages. As several lights are always used together, it is never necessary for more than one of them to pass through the exact zenith at the same time.

The searchlight is transported on a truck which will be described later. This truck also carries the searchlight personnel and provides the power for operating the light. Since the light is carried and not towed, it is not necessary to provide the light with a heavy, spring suspension chassis. This decreases weight and adds to ease of handling when placing in position for antiaircraft action.

Scales graduated in degrees are provided for reading the position of the searchlight in azimuth and elevation. All meters and scales are illuminated. A small incandescent light is secured inside the drum for use when recarboning the searchlight at night. An engraved instruction plate on the searchlight gives all essential information regarding operation.

Two sets of levels and four screw jacks are used to adjust the searchlight turntable to the exact horizontal plane when preparing for action. The open sight, indicated in Fig. 4, is used in daylight practice and for orienting the searchlight to the same base line as the sound locator. Stray light shields are used to cut off the reflection of the arc tail flame and so insure a well defined beam.

Fig. 7. The light-tight cover shown here is the simplest means for occulting the light.

The Sperry antiaircraft searchlight with its rugged yet accurate lamp mechanism, its strong yet light construction of drum and chassis is the result of a long period of evolution in laboratory and in service. It combines to a rare degree the qualities of precision, strength and simplicity—a combination difficult to attain in any branch of engineering.

When using the searchlight, it is frequently desirable to cut off the light while keeping the arc in operation. The searchlight is therefore provided with a shutter. The simplest form of shutter is the light-tight front lens cover shown in Fig. 7. With a little experience, the cover can be put on and taken off in a fraction of a second. This method of occulting the light has the advantage of light weight.

When the searchlight is to be used for signaling, or other purposes requiring very rapid occulting, it is provided with a radial vane signal shutter. This shutter comprises a number of radial vanes controlled by a central gear which engages with a pinion at the inner end of each vane. The shutter can be opened and closed rapidly and easily. When closed, it is light tight, thus eliminating the need for any additional method of occulting.

Sperry antiaircraft searchlights are also equipped with a distant mechanical control. This control is sometimes employed when training personnel or when using the searchlight for signaling. For antiaircraft purposes, the preferred method is the distant electrical control described in the following paragraphs.

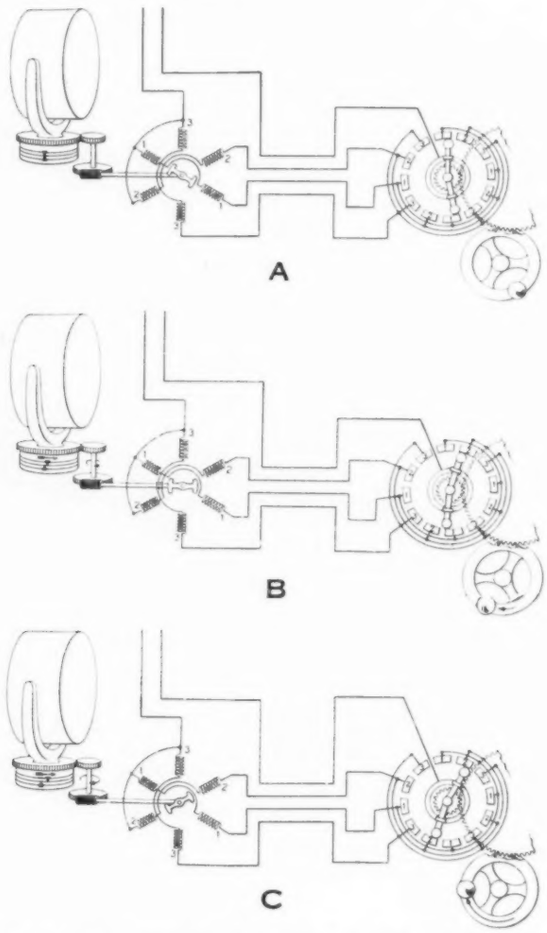

Fig. 8. The elementary principle of the distant electrical control.

THE diagram given in Fig. 6 (Part I of this series, page 313, March-April issue of this Journal) shows the need for distant electrical control. By moving the controlling observer well to one side of the light, the depth of illuminated atmospheric particles through which he has to look is reduced, the contrast is thereby improved and the range is greatly increased.

It has been found from experience that the distance between controller and searchlight should be at least 50 feet (15.3 meters). Each increase in distance up to that point brings about a substantial increase in range. Increases beyond 50 feet (15.3 meters) produce some increase in

range but not very much. The distance of 50 feet (15.3 meters) is large in comparison with the diameter of the beam near the light—consequently a distance of this value gives 90 per cent of the advantage to be gained by movement to one side. To obtain the remaining 10 per cent it would be necessary to move several thousand feet. Since the distance of fifty feet must be obtained with various conditions of terrain, it is necessary to provide for at least two hundred feet of cable between the controller and searchlight. As mechanical control at this distance would be impracticable, it is necessary to provide a suitable electrical control.

Fig. 9. Distant electrical controller. The searchlight accurately follows all movements of the hand wheels.

The requirements which the distant electrical control should meet are as follows:

(1) To permit of following the target accurately, at all ranges and angles of approach, it should be capable of any speed of movement between three revolutions per minute and one revolution in three hours.

(2) To avoid interference with listening devices, it should be perfectly silent in operation.

(3) To permit of accurate and convenient following of the target without a highly skilled operator, it should be synchronous, that is to say, the searchlight should follow the movements of the controls in the hands of the operator—move when he moves, stop when he stops and follow accurately all of his varying rates of movement.

(4) To avoid any danger of losing the target the method of transmission between controller and searchlight should, if it employs the step-by-step system, have steps not larger than ¼ degree—i. e., one-quarter of the width of the beam.

(5) To avoid any danger of getting out of synchronism, the training and elevating motors must have a high torque at all rates of speed.

An indication of the difficulty of obtaining a perfectly satisfactory distant electrical control is given by the fact that in the past fifteen years more money has been spent on this development than on the searchlight itself. Controls have been developed which met every requirement but synchronous operation, others which met every requirement except high torque at all speeds, still others which were satisfactory except for noisy operation. The control which we are about to describe is the first to meet every requirement. It also has the additional advantage of simplicity with consequent ruggedness and ease of maintenance.

Fig. 10. A binocular may be mechanically connected to the controller in such manner that it automatically follows the searchlight beam.

THE principle employed in the distant electrical control is well known and has been used for many years in connection with the gyro-compass and other devices incorporating electrical transmission systems. The application to searchlight control differs from all previous applications in that the receiving motor must be capable of exerting considerable power at all rates of turning.

The elementary principle of the control is illustrated

diagrammatically in Fig. 8. Only the azimuth (training) control is shown. The elevation control is precisely the same in principle. The commutator transmitter shown on the right of the diagram is located in the controller at a distance from the searchlight. The radial contact arms of this transmitter are driven by the hand wheels of the controller. The armature of the receiving motor at the left of the diagram drives the azimuth gear of the searchlight.

When the radial contact arms are in the position, shown by Diagram A, Fig. 8, the current is conveyed through the arms to the No. 1 segments of the commutator and thence to the No. 1 pair of coils of the receiving motor at the searchlight. Thus the armature of the motor is held in the position shown in the diagram. A clockwise movement of the radial arms will bring the upper arm in contact with the No. 2 commuator segment while the lower contact arm

Fig. 11. The searchlight locked in the vertical position preparatory to being placed on the power unit.

is still touching the No. 1 segment as in Diagram B. Thus both the No. 1 and No. 2 pairs of coils of the receiving motor will be energized and the armature will be drawn half way between them. The next movement at the transmitter, Diagram C, will place both radial arms on No. 2 segments, thus moving the receiving motor armature to a position in line with the No. 2 coils. Twenty-four steps occur for each revolution of the transmitter and twelve for each revolution of the receiving motor armature. By suitable gearing each step produces a movement at the searchlight of one-eighth of a degree. The speed of movement may be anything from zero to three revolutions per minute.

The controller is shown in Fig. 9. As explained in the preceding discussion, the controller comprises an elevation commutator transmitter, a training commutator transmitter, and trains of gears connecting the contact arms of each transmitter with the hand wheels which control them. One turn of either hand wheel moves the searchlight through 5 degrees. It is quite feasible for one man to control the searchlight in both elevation and azimuth although two are sometimes employed. Movement of the training hand wheel turns the controller in azimuth. Therefore the operator always faces toward the target.

The controller is sometimes fitted with a binocular which is driven to follow the movements of the searchlight in both azimuth and elevation. This is shown in Fig. 10. The binocular control improves the range but cannot be conveniently used when coördinating the searchlight with the sound locator.

The elevating and training motors at the searchlight are shown in Fig. 11. Acting through suitable gear trains, these motors produce torques around the vertical and horizontal axes of the searchlight of 42 foot pounds which is considerably more than is required for the most severe conditions. Clutches are provided for disconnecting the control motors in case it is desired to use the hand control.

(*Part III, which will conclude this discussion, will be published in the next issue of this Journal.*)

History of Explosions

THE Institute of Makers of Explosives has performed another very valuable service to the explosives industry and to users of explosives in the publication recently of a volume entitled "History of Explosions," compiled under the auspices of the Institute by Mr. Ralph Assheton, a member of the Army Ordnance Association. The data comprising the history are those on which the American Table of Distances was based. In addition, descriptions of other explosions of major importance are included. Among the 117 major explosions described, for instance, the Lake Denmark disaster of July 10, 1926, is fully covered with a map and 21 pages of text constituting probably the most complete description of that series of explosions and their effects yet made public.

The volume, which is splendidly arranged, includes a foreword by the author and an introduction by Lt. Col. B. W. Dunn, Ord. Dept., Ret., Chief Inspector for the Bureau of Safe Transportation of Explosives and Other Dangerous Articles.

The Institute for Makers of Explosives for many years has been collecting data on the various great explosions which have occurred from time to time and upon which there is accurate information as to the quantity and type of explosive and the distance and nature of resulting damage. Based on these data the American Table (published in the book in curve and tabular form) indicates the distances from railroads, public highways and inhabited buildings in which various quantities of explosives may be stored.

In his introduction to the work Colonel Dunn states:

"In making a study nearly twenty years ago a valuable service to all interested in the subject was performed by the manufacturers of explosives, and this service will be extended materially by the Institute of Makers of Explosives in publishing the facts on which the American Table of Distances was based. These facts will add to the confidence with which that table is accepted and applied.

"The table has been incorporated in the laws of a number of States, including California, Kentucky, Massachusetts, Montana, New Jersey, New York and Ohio, and it has been recommended by the National Fire Protection Association in its code of model ordinances for villages and municipalities. If a court were asked today to enjoin the location of a storage magazine at a given distance from other property and under given conditions this table would be the only guide in predicting the probable effects of an explosion."

Stove Tests of Range Finders

An Apparatus for Correcting Temperature Variations

By the Duke de Gramont*

THE construction of range finders meets with two principal difficulties: in the first place, the instrument must not be affected by shocks and vibration to which it is liable to be subjected; secondly, the indications given by it should be practically independent not only of the surrounding temperature, but also of the changes of that temperature while they are taking place.

In our climate the variations of temperature may be somewhat marked during fine weather, especially when the apparatus passes from shade to sunlight or vice versa. In winter, the variations are very much slower. Artificial variations can be created by leaving the instruments in a warmed chamber during the night, upon their removal, at the beginning of the tests, differences of temperature are obtained which may amount to 20° or 30° F. but always of the same value. The artificial variations of temperature that may be obtained in this way sometimes reveal certain defects in an apparatus.

In a more general way, by open-air tests of a series of range finders it is sometimes possible to interpret the abrupt changes of the curve of differences in the function of temperatures, thus allowing the defects to be localized and corrected.

Seeing that rapid variations of temperature can reveal the imperfections of an instrument by increasing their importance, it appeared to be of interest to be able to cause and graduate these variations at will while giving them an arbitrary value. In addition, it would be necessary that the temperature be steadily maintained at the de-ired level, and that, during these operations, the measurements could be continued without interruption.

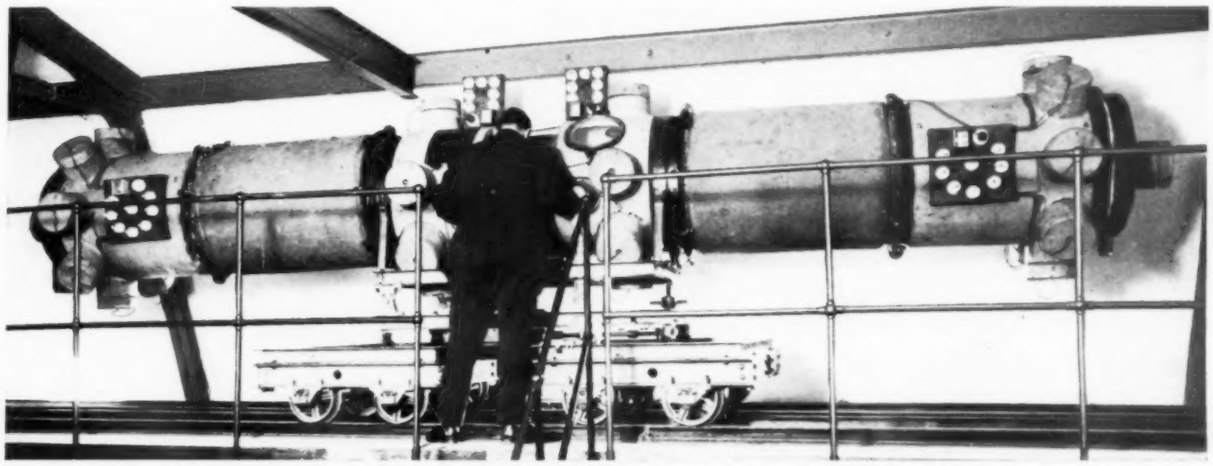

Fig. 1. Stove for Testing Instruments of 3 to 10 Meter Bases.

To this end, and at the request of the technical departments of the French Navy, we have arranged the stoves of which we give a brief description below. We shall then reproduce the temperature curves obtained with stove-tested range finders which may be compared with analogous curves obtained in the open air, both in the shade and the sun.

Such a test chamber will render great service in the testing of new models and the comparison of varied devices. On the other hand, it will facilitate the reception tests of a given material by giving the tests a constancy not permitted by the variations of the surrounding atmosphere.

THE problem to be solved consisted of the creation around the telemeter of an atmosphere whose temperature could be regulated. Furthermore, the observer should have access to

*President, Levallois Company, Paris, France.

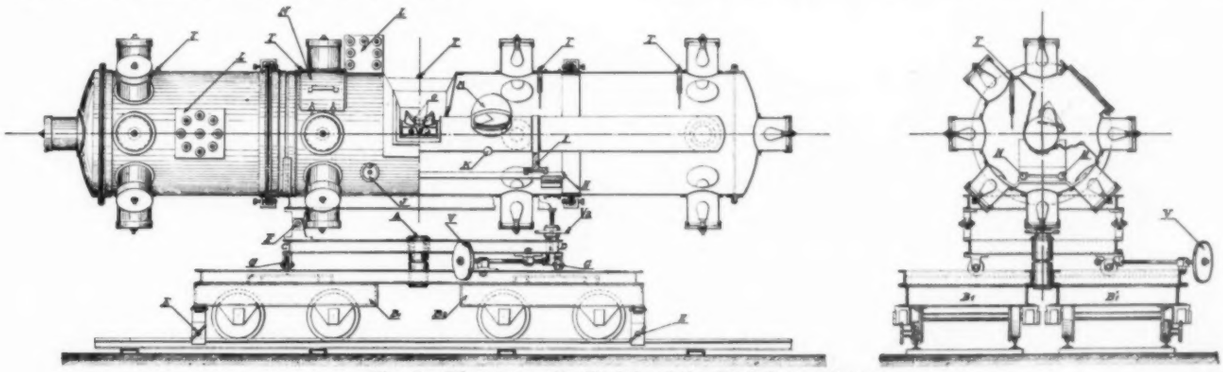

Fig. 2. Diagrammatic Sketch of the Test Apparatus.

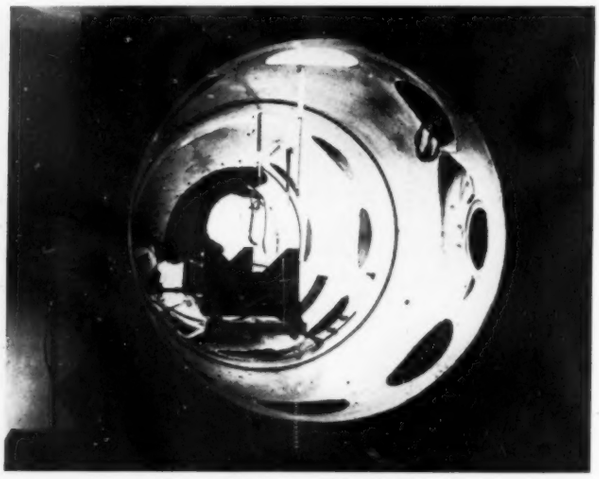

Fig. 3. Interior of the Stove.

the eyepieces during the entire duration of the experiment, and, by means of entrance windows, exterior images should be formed in the range finder without the interposition of any kind of glasses. Lastly, the stove must be capable of enclosing range finders of varying length.

We commenced with a stove intended for instruments with a base of at least three meters; as will be seen, it can be extended up to ten meters. The general idea is shown in Fig. 1.

In a room sufficiently long to contain the largest range finders under consideration at the present time, two 0 m. 60 narrow-gauge tracks are arranged parallel to each other on a platform. On these rails two pairs of bogies can travel (B_1, B'_1 and B_2, B'_2), (Fig. 2) serving as support to the stove itself by the intermediary of the chassis (CD) moving around the axis (A). The chassis (CD) rests by means of four rollers (G) on the plane carried by the bogies. These latter are wedged on the rails by a species of clamp (E). There is, however, no necessity to move the bogies unless the length of the stove is altered.

The movement of the wheel (V) turns the chassis (CD) round the axis (A), and brings about the adjustment in azimuth of the stove, and consequently, of the range finder inside it. The wheel (V_2) causes the stove to oscillate round the axis (F) and thus brings the telemeter into a horizontal position.

Inside the stove two parallel steel bars are arranged on which move two parts (I) forming a V on which the range finder collars rest. Fig. 3 shows, at the end, the inside of the stove.

The direction and horizontal adjustments of a range finder are thus obtained by the movements—which, however, are very limited—of the stove itself: a sight is, in fact, arranged in fixed position, parallel to the axis of the rails. With regard to the site adjustment of the range finders, this is obtained by operating the rapid movement lever of the telemeter by means of the handle (J) and a small connecting-rod.

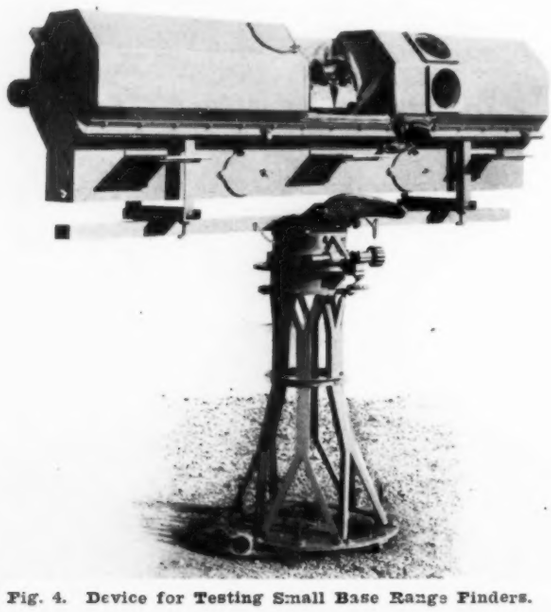

Fig. 4. Device for Testing Small Base Range Finders.

THE stove is composed of three parts made of steel sheeting, painted white inside and heat-insulated outside. The central part is hollowed out in order to allow the observer

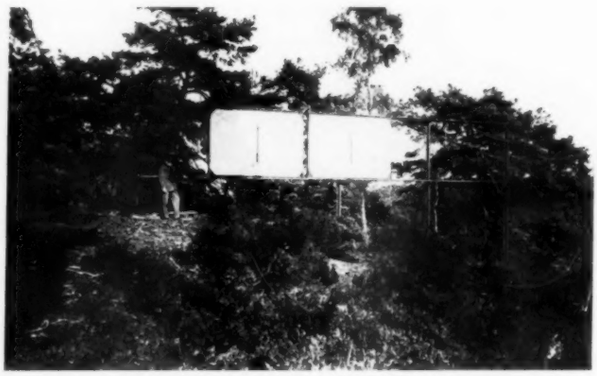

Fig. 5. Sight Used for Testing Large Base Instruments.

to look into the eyepieces (O). The latter come out to the exterior of the stove, the junction of the stove and the eyepiece plate being made tight by means of rubbered cloth and an elastic binding.

The tightness of the opening where the observer can put his arm through into the stove and move the distance milled wheel (K), is effected in a similar manner. This milled wheel can also be mechanically controlled from the outside. The reading of the distance drum is made at (M) through a glass.

A moveable plaque (N) affords access to the left-hand side of the telemeters where the height adjustment mechanism is located, which is not touched during a test.

The central part just described is about 1 m. .50 in length. To its extremities two cylindrical sections are fixed fitted with openings placed opposite the entry windows of the telemetric tube. Additional sections are provided for larger range finders. The extremities of the stove are closed by moveable circular parts.

Connecting the various elements to the central part effects at the same time the electrical connections and allows the lighting of a series of carbon filament lamps located in the heat-insulated compartments seen in Figs. 1 and 2. These lamps are arranged at the summits of a series of octagons in the planes of the right section of the cylinder constituting the stove; in addition, a lamp is placed at

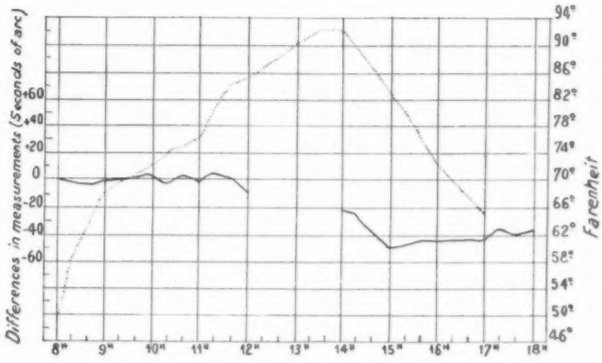

Fig. 6. Results from Range Finder in Stove.

each extremity according to the axis of the cylinder. All the wires are connected to the switchboards L (Fig. 2).

To prevent local heating of the telemeter, the latter is separated from each series of lamps by a band of brass wire gauze fixed according to a cylinder of the same axis as the range finder.

The lamps can be lighted independently of each other so as to create temperature variations inside the stove and to reproduce in particular the dissymmetry produced by solar

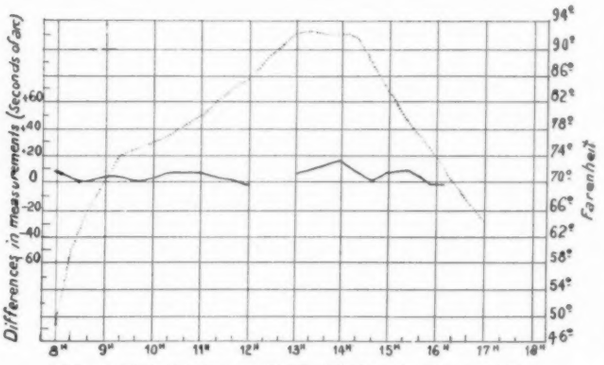

Fig. 7. Results from Range Finder in Stove after Improvement..

heat. Thermometers (T) distributed throughout the stove permit all these temperature variations to be followed; in addition a recording thermometer gives a characteristic curve of the test during its entire duration.

Lastly, athermic partitions, appearing as right sections of the stove, may be fixed so as to isolate an element under observation the temperature of which may vary to the exclusion of the others: a terminal optical square or the central block, for example.

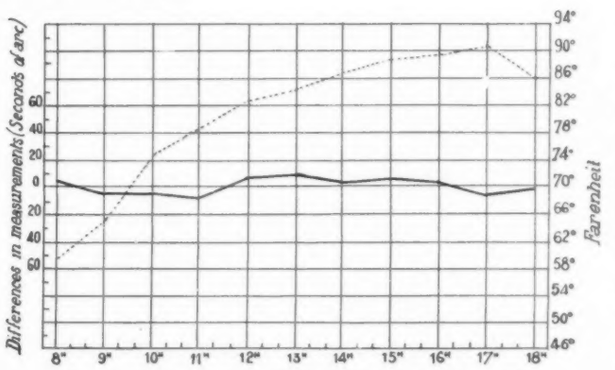

Fig. 8. Results from Range Finder in Open Air.

THE apparatus in the form just described will serve for all dimensions of telemeters greater than three meters. It is only necessary to add symmetrically to the central part cylindrical sections of suitable length in order to obtain the entire range of the bases desired. For long telemeters over six meters base, the stove is supported by intermediary carriages.

The wall of the testing room along the length of the range finder is pierced with a certain number of port holes of small diameter, permitting the test of telemeters of different sizes. Only the two port holes corresponding to the base of the apparatus are opened. By thus reducing connection with the outside, an attempt has been made to diminish the disturbances caused around the entry windows by the differences between the test-room temperature and that of the outside atmosphere. Nevertheless, the "waving" caused by the hot surface of the stove was such that the measurements became very difficult to take. The existing sun shields of the telemeter were therefore replaced by cylindrical tubes (P) 60 cm. in length, introduced into the stove and the wall port holes, as described above for the eyepiece plaque. These heat-insulated tubes are led off outside the building; the air heated by contact with the stove no longer interferes with the reading.

For small base range finders, we have established a more simple device. It is preferable in this case to construct a stove for each type of telemeter. Fig. 4 represents a stove intended for a 1 m. .50 telemeter. It consists of a mahogany box of octagonal section divided into two parts according to an axial plane at 45°. The box can be opened for the introduction of the telemeter; tightness is insured by a rubber joint gripped between two corner irons.

Heating is obtained by means of a range of ten carbon filament lamps arranged in a groove placed at the bottom of the stove. Three slides placed perpendicularly to the ends and center of the telemeter allow its various parts to be heated in turn or simultaneously. As this stove is rather light it is mounted on a tripod the head of which is fitted with an iron part parallel to the range finders. The stove can be moved slightly on this iron part so as to permit the desired site.

A sight intended for big base instruments is installed in a fixed position about half a mile from the test room. It consists of two large metallic panels (Fig. 5) each bearing a vertical mark on a light background, which can be moved by means of rollers between two horizontal rails. The marks are brought to a width equal to the base of the range finder and sighting is then made to infinity.

By bringing the panels closer together fictitious points of variable distance can be created.

It was difficult to foresee what might be the losses in calories of the stove by convexion or radiation. Tests with lamps of different intensities showed that 12 to 14 lamps of 16 to 32 candlepower lighted four times sufficed to raise the temperature inside the stove from 50° to 100° F. in from four to five hours. By putting out all the lamps simultaneously, the temperature dropped by about 20° in one hour.

STOVE tests have brought to light a certain number of points which, up till now, remained obscure. In the first place, the time taken by the range finder to adjust itself in temperature when heated outside is shown.

For a large telemeter, heat-insulated in the usual manner, three to four hours are required for the differences measured to show the influence of the change of temperature. If the stove is heated in a shorter time and then allowed to cool, the telemeter retains its adjustment.

We have therefore been led to make stove tests by following the daily temperature cycle. The stove is lighted in the morning, the level is reached about mid-day and the lamps are put out late in the afternoon, the extreme differences of temperature being about 30° or 40° F.

Under these conditions, we were able to ascertain that the range finders behave in the stove as in the open air, but the method has the advantage of subjecting a given instrument to a series of identical tests, which, in consequence, furnish results that can be compared.

If an apparatus does not give satisfaction at the first test constituted by heating the whole, it is subjected to three distinct tests: heating the right side, the left side and the central block. The examination of the three curves obtained shows the defective part, which is either modified or replaced.

For example, Figs. 6 and 7 reproduce the two curves obtained with the same 3-m. base telemeter, 25 magnification, before and after retouching. The times are given in abcissae, in ordinates are shown the temperature (dotted line) on the one hand, and on the other, the differences corresponding to the successive spotting expressed in seconds of the amplified field (continuous line). Each point represents one spotting only. The diagram in Fig. 6 shows variations of 55 seconds which, for a temperature difference of 40° F. clearly denotes a defect in the apparatus. After partial heating experiments, it was found that an optical square was defective. After the replacement of the part at fault, the instrument gave the curve reproduced in Fig. 7. The divergence is not more than 18 seconds for the same difference of temperature.

The diagram in Fig. 8 shows that the performance of this telemeter, after being put right, was appreciably the same in the stove tests as in the open air, in shade and sunshine.

The stove shows defects of an apparatus that are frequently hidden by the slight errors of the telemetrist, or which do not show themselves during the periods when the surrounding temperature varies but little.

Thanks to the moveable partitions, the defects of an instrument may be localized and systematic tests may be carried out on a determined part. We seem then to have here an apparatus for checking and research work from which real improvements may be expected.

Muscle Shoals Plant Inadequate for National Defense.

MAJ. GEN. C. C. WILLIAMS, shortly before his retirement as Chief of Ordnance of the Army, testified before the House Military Affairs Committee on March 26th that the Government plant at Muscle Shoals—for many years a white elephant in the political arena—was justified at the time of its construction during the World War but that part of it could be wrecked without affecting preparedness for national defense. General Williams, in his testimony, opposed Government manufacture of products the supply of which is assured by private industry.

Representative Speaks, of Columbus, Ohio, asked if the plant had been completed within the requirements of that law. General Williams said the original act had purposed an appropriation of $20,000,000, but that a great deal more had been expended by the Government.

The plant is not equipped to manufacture fertilizer, never has been so equipped and could not be so used without considerable expenditure, General Williams said. The plant does turn out ammonium nitrate, he said, but it is not used for fixation of nitrogen for use in fertilizer, although it could be converted for that purpose with considerable changes and expense.

Mr. Speaks reminded the witness that Muscle Shoals was for the purpose of manufacturing munitions in war time and to "stand by" with fertilizer production in peace time, and he asked the witness if the plant is sufficiently developed to meet the requirements of the law that originally created it. General Williams replied, "As to fertilizer, decidedly no." He said that Nitrate Plant No. 2 is in exactly the same condition as it was at the time of the Armistice, it can do as much and no more than it could do then. "It can turn out," he added, "ammonium nitrate which is one of the ingredients of high explosives.

"One of the great essentials for use in time of war," General Williams continued, "is explosives and there are various kinds of explosives as munitions." Sulphuric and nitric acids, treated with some other substances, such as cotton for gun cotton, are used. The United States is one of the largest producers of sulphuric acid, so that there are sufficient domestic resources of sulphuric acid and there need be no national concern over that material. Nature was not as generous to the United States in the essential raw materials for nitric acid, he continued.

The main source of sodium nitrate is Chile, upon which country the United States was dependent at the outbreak of the World War, but there had since been considerable development in this country along that line and Germany, he added, has taken the lead in two processes, including a cyanamide process. Discussing Nitrate Plant No. 2 at Muscle Shoals, he said the cost of that plant was $67,500,000. The plant met the purpose for which it was intended and Nitrate Plant No. 1, which was not a success, cost $12,800,000.

Asked regarding readiness of industry for conversion for war supplies, the general replied that "it would take from nine months to one and one-half years for adjustment of private industry so that it will be ready to produce a full supply of materials necessary for war explosives."

"You would not want to say that we might just as well wreck Muscle Shoals?" asked Mr. McSwain.

"I have not said that," replied the general, "but there is a certain part of the plant you could wreck without danger to the national defense. I did not say that you could wreck all of it."

He added that he thought "the Government should not manufacture anything production of which is assured in ordinary commerce," but that it must manufacture essential things that cannot be assured in industry.

Association Affairs

New York Post

THE New York Post, Army Ordnance Association, held its Spring Dinner at the Hotel New Yorker on April 21st. A large group of manufacturers and industrial leaders was present. Maj. E. G. Curtis, Ord. Res., presided and introduced the three speakers of the evening.

Mr. P. R. Bassett, Chief Engineer of the Sperry Gyroscope Company spoke on "Ordnance and Modern Warfare," commenting particularly on the changes in methods of warfare made necessary by the development of aircraft, and describing recent progress in the development of anti-aircraft fire control.

Maj. C. T. Harris, Ordnance Officer, Second Corps Area, reviewed the history of the Ordnance Department, commenting particularly on the successive Chiefs of Ordnance who have guided the policy of the Department. Major Harris spoke with enthusiasm of the accomplishments of Maj. Gen. C. C. Williams and expressed the unanimous feeling of the Post in regretting General Williams' retirement and in wishing him many happy days.

Lt. Col. G. L. McEntee, Inf., U. S. Army, concluded the evening with his famous lecture on "Turkey in the World War." Colonel McEntee has had exceptional opportunities for compiling data on some of the lesser known campaigns on the Eastern Front and his presentation of the subject was most interesting.

Washington Post

THE regular monthly meeting of the Washington Post, Army Ordnance Association, was held at the Army and Navy Club on April 9th following luncheon which was served to approximately forty-five members and guests.

Lt. Col. C. G. Mettler, President of the Post, presided, and committee reports submitted included that of the Ordnance Committee of the Post read by Professor Hardee Chambliss in the absence of Dr. C. G. Storm, Chairman of the Committee. The report referred to the accident at the Picatinny Arsenal in which Capt. J. B. Fidlar and two civilian employees lost their lives. Tribute was paid to the work of Captain Fidlar during his service in the Ordnance Department. The report also described in general terms recent powder developments.

The honor guests at the luncheon meeting were Dr. Ambrose Swasey, of Cleveland, Ohio, and Col. Theodore J. Hoover, Ord. Res., who is dean of the School of Engineering, Stanford University, and a director of the California Post, Army Ordnance Association. Brig. Gen. C. L'H. Ruggles, Acting Chief of Ordnance, and Brig. Gen. Samuel Hof, Assistant to the Chief of Ordnance, also were present.

Dr. Swasey, one of the few living founders of the American Society of Mechanical Engineers, and an outstanding figure in the manufacture of precision instruments, gave a very delightful talk on his long period of contact with the Ordnance Department. Colonel Hoover described the course for Ordnance Reserve Officers which, under his direction, has been in operation at the Stanford University for several years. During his visit to Washington he was the guest of his brother, President Hoover, at the White House. Nevertheless he found time to serve on an inactive duty status in the Office of the Chief of Ordnance. Because of the many social activities which his stay at the Executive Mansion necessitated, he was not able to tie himself down to the program he would have to follow if he had taken a tour of active duty.

He was able, however, to give a few hours each day to duty, where most of his work was performed in the offices vacated by Maj. Gen. C. C. Williams when he retired as Chief of Ordnance. Colonel Hoover devoted his studies and conferences to war plans and industrial mobilization problems.

General Ruggles, in presenting Dean Hoover, spoke briefly on the aims and purposes of the Army Ordnance Association and its place in the general plan for industrial preparedness.

Due to the eminent standing of the honor guests and the excellent addresses delivered the meeting of the Washington Post was exceptionally instructive and interesting.

Milwaukee Post

THE annual banquet of the Milwaukee Post of the A. O. A. was held in the Club Room of the Hotel Pfister in Milwaukee on Tuesday evening, April 29. This was a joint meeting with the Milwaukee Chapter of the Reserve Officers Association, due to the fact that, by a remarkable coincidence, each organization had arranged a meeting for the same evening with a speaker on the same subject, which was only discovered when each attempted to solicit the membership of the other to attend its own meeting. The two speakers rounded out the occasion, as one dealt with the matériel and the other with the personnel of antiaircraft.

Herbert V. Kohler, one of the directors of the Milwaukee Post presided. Among the guests were: Hon. Francis McGovern, formerly governor of Wisconsin; Col. G. R. Greene, F. A., Chief of Staff of the 101st Division; Lt. Col. John C. Davis, C. A. Res., Commanding Officer of the 506th A. A. Regiment; Lt. Col. Watson M. Myers, Ord. Res., formerly Commandant of Watertown Arsenal; Maj. R. B. Coeroft, C. A. C., Adjutant General of the 101st Division; and Capt. W. P. Hirshberg, Eng. Res., president of the Milwaukee Chapter of the Reserve Officers Association.

Before the dinner, Spencer Hayward, of South Milwaukee, disguised in the full uniform of a major general, and accompanied by Miss Inez Westberg, the head of the Music Department of the South Milwaukee High School,

sang several selections, including the major general's song from "The Pirates of Penzance."

The speakers for the evening were Maj. W. P. Boatwright, Chief of the Artillery Section, Office of the Chief of Ordnance, who spoke on "Latest Developments in Antiaircraft Artillery," illustrating his remarks by stereopticon slides of the latest matériel; and Col. H. C. Barnes, C. A. C., Chief of Staff of the Coast Artillery (A. A.) Group of the 6th Corps Area, who spoke on "Organization and Tactical Control of Antiaircraft Artillery Units," illustrating his remarks with diagrams and with two films showing antiaircraft units in action.

The arrangements were in charge of a committee headed by Mr. Knight Charlton of the Milwaukee Post, A. O. A.

Pittsburgh Post

IN connection with the announcement which appeared in the March-April issue of ARMY ORDNANCE relative to the annual meeting of the Pittsburgh Post, Army Ordnance Association, on March 5th, mention should be made of two preliminary meetings which were held by officers and members of the Pittsburgh Post preceeding the meeting.

At noon at the Pittsburgh Golf Club, Mr. A. B. Shephard, Vice-President of Jones & Laughlin Steel Corporation, gave a luncheon in honor of Maj. Gen. Lytle Brown, Chief of Engineers and Brig. Gen. C. L'H. Ruggles, Assistant to the Chief of Ordnance, at which the following were present: George G. Crawford, President, Jones and Laughlin Steel Corporation; Ralph M. Dravo, District Chief, Pittsburgh Ordnance District; F. R. Dravo, President, Dravo Contracting Company; W. S. Finlay, President, West Penn Power Company; William F. Rust, Vice-Pres., Koppers Company; Robert E. Withers, Vice-Pres., Aluminum Company of America; Lt. Col. Jarvis J. Bain, District Engineer; Taylor Allderdice, President, Pittsburgh Post, Army Ordnance Association, and A. B. Shephard, Vice-President, Jones and Laughlin Steel Corporation.

Mr. Ralph M. Dravo gave a breakfast at the Duquesne Club for the distinguished guests. Those at the breakfast in addition to General Brown and General Ruggles and Mr. Dravo were: Dr. Thomas S. Baker, President, Carnegie Institute of Technology; Lt. Col. Jarvis J. Bain, District Engineer; Lt. Col. R. L. Howell, District Engineer, Wilmington, Delaware; Lt. Col. H. A. Gidney, Ord. Res., Assistant Ordnance District Chief; A. N. Diehl, Vice-Pres., Carnegie Steel Company; Col. Elbert A. Gibb, Eng. Res.; Maj. E. L. Messler, Eng. Res., President, Pittsburgh Post, Society of American Military Engineers; Capt. Fred A. McMahon, Ord. Dept., Executive Assistant, Pittsburgh Ordnance District; Mr. F. R. Dravo, President, Dravo Contracting Company; Mr. J. D. Berg, President, Dravo-Doyle Company; Mr. V. B. Edwards, Vice-Pres., Dravo Contracting Company, and Mr. J. S. Miller, Director, Dravo Contracting Company.

Birmingham, Ala.

THE formation of a local post of the Army Ordnance Association in Birmingham has again been given consideration during the past few months. A committee consisting of Mr. George Morrow, Vice-President, Goslin-Birmingham Machine Company, Major C. H. Menger, Ord.-Res., Alabama Power Company, Captain Chas. R. Thompson, Ord.-Res., Alabama Power Company, 1st Lt. D. N. Hauseman, Ord. Dept., Executive Assistant and Lt. Robt. E. Smith, Ord.-Res., Alabama Power Company, was appointed to investigate the advisability of organizing a post at this time. Investigation revealed that the present call for ordnance work on our plant executives and on our Ordnance Reserve Officers in Birmingham was extremely large. As a result it was believed advisable to postpone the formation of a post, at least until fall, when some of the work will be completed. At that time the matter will again be given consideration.

The former chairman of the Birmingham Ordnance District Advisory Board, Mr. George Gordon Crawford, has left Birmingham to become President of the Jones and Laughlin Steel Corporation, Pittsburgh. Appointment of a new Chairman of the Board is expected shortly.

Bridgeport

A MEETING of reserve officers and manufacturers of the Bridgeport District was held at the plant of the Remington Arms Company, Bridgeport, Conn., the evening of April 3, 1930. Preceding the meeting, a dinner was served in the Remington Arms Club.

Among the guests present at the dinner and meeting were Mr. W. R. Webster, Vice-President of the Bridgeport Brass Company, a member of the District Advisory Board, Mr. A. A. Dicke, Vice-President of the Remington Arms Company, Col. L. J. Herrmann, Works Manager of the Bridgeport plant of the Remington Arms Company, Mr. A. L. Lowe, Works Manager of the Ilion plant of the Remington Arms Company, Mr. E. Hadley, Assistant to the President of the Remington Arms Company, Lieut. Col. Townsend Whelen, Ord. Dept., Lieut. Colonel J. D. Skinner, Ord.-Res., Messrs. D. C. Griggs and Z. P. Candee, Vice-Presidents of The Waterbury Farrel Foundry and Machine Company, Waterbury, Conn., and Mr. Russell S. Fenn of Sargent and Company, New Haven, Conn.

The principal guest and speaker at the meeting was Lieut. Col. Townsend Whelen, Ord. Dept., now on duty at Springfield Armory. The subject of Colonel Whelen's address was "Procurement of Small Arms and Small Arms Ammunition." Colonel Whelen gave an interesting account of the development of the military rifle in the United States, beginning with the so-called Kentucky Rifle made in the early days by German and Swiss gunsmiths who had immigrated to Lancaster County, Pa. He spoke of the enormous demands that would be placed on the small arms and small arms ammunition plants in time of war and pointed out the importance of amending existing law so that small educational orders for such items could be placed in time of peace.

THE annual meeting of the Bridgeport District will be held at the Hotel Bond, Hartford, Conn., on Friday, June 6th.

The committee in charge of arrangements for this meeting includes Mr. S. M. Stone, President of the Colt's Patent Fire Arms Mfg. Company, Chairman; Mr. John H. Goss, Vice-President, Scovill Manufacturing Company, Waterbury, Conn.; Mr. H. H. Pease, President, The New Britain-Gridley Machine Company, New Britain, Conn.; Mr. W. R.

Webster, Vice-President, Bridgeport Brass Company, Bridgeport, Conn.

Cleveland

COL. T. C. Dickson, Commanding Officer of the Watertown Arsenal, Watertown, Mass., will be the principal speaker at the meeting of the Cleveland Engineering Society to be held in Cleveland on the afternoon of May 15th. Colonel Dickson will discuss centrifugal castings, cold working of tubes and welding developments in connection with gun carriage design. His address is sponsored by the Military Division of the Cleveland Engineering Society and will be given before the entire membership and the affiliated Engineering Societies. All members of the Army Ordnance Association in the vicinity of Cleveland will be invited to attend.

The Veteran Corps of Artillery, New York

BRIG. Gen. Charles Elliot Warren, Treasurer of the Army Ordnance Association since its organization, Vice-President of the Irving Trust Co., New York, and an outstanding figure in financial, industrial and military activities, reviewed, in his capacity as Colonel Commandant of the Veteran Corps of Artillery, New York, the 369th Infantry Regiment, New York National Guard, at the latter's Armory on April 30th. The invitation to review the regiment was extended by Col. Wm. A. Taylor, its commanding officer, in compliment to the Veteran Corps of Artillery. General Warren was accompanied by a guard of honor in the picturesque dress uniform of the organization with colors, guidon and field music.

As stated in general orders of Veteran Corps of Artillery the 369th Infantry made an enviable record as a part of the 16th and the 161st Divisions, 8th Corps of the Fourth French Army, having arrived at Brest, France, December 27, 1917. It had the distinction of being numbered among the first 100,000 American combat troops to reach the battlefields. In April, 1918, it took over a front line sector and participated in five campaigns, thirteen battles. Its colors were decorated with the Croix de Guerre. Two hundred and seventy-nine of its officers and men were killed, 737 were wounded. The organization served 191 days in the front line trenches and in battle it was the first American negro regiment in action. The colors carry streamers and rings, and particularly the special blue streamer, signifying that the regiment has been cited in orders for conspicuous gallantry in action.

Killed in Line of Duty at Picatinny

THE Picatinny Arsenal suffered a severe loss in the deaths of Capt. John B. Fidlar, Ord. Dept., Chief of the Plant, Engineering Division, and Messrs. Stephen D. Deevy and Frank Stevens, Jr., both of the same division, who were accidently killed at the Arsenal on March 21st, while conducting a test in the powder factory. The exacting safety precautions in effect at the arsenal prevented an even larger toll of lives, six employees having been required to leave the room in which the test was being conducted shortly before the explosion occurred.

Captain Fidlar, was born at Davenport, Iowa, March 16, 1892, where he spent his childhood. He entered the Iowa State College of Agriculture and Mechanical Arts in 1912, graduating in 1916 with the degree of B. A. in M. E. Following his graduation he spent some time in Missouri and Oklahoma investigating oil resources. He entered the United States Army as Second Lieutenant, F. A. Sec., O. R. C. on August 16, 1917, was commissioned Second Lieutenant, Field Artillery, October 26, 1917, First Lieutenant December, 1918; transferred to the Ordnance Department July 1, 1920. He received a Silver Star citation for bravery in action in France, where he participated in a number of major operations.

On his first tour duty at Picatinny Arsenal he was in charge of the proving ground. He spent much of his time in standardizing the arsenal's methods of making tests and devising new methods which have since become standards.

After leaving the arsenal he was on duty for several years with the Organized Reserves and stationed in New York City. Before returning to Picatinny for his second tour of duty he spent one year in Wilmington, Delaware, studying smokeless powder production as carried out during the World War. On his second tour of duty at the arsenal he was Chief of the Plant Engineering Division, which position he held at the time of his death.

Mr. Stevens was born at Port Morris, New Jersey, December 17, 1904. He was first employed at the arsenal in June, 1921 and after acquiring some experience was assigned work as an explosive operator. He had experience in both high explosive, and propellent powders and had proved himself a conscientious, reliable and careful worker and was well liked by his associates.

Mr. Deevy was born March 29, 1895 at Fall River, Mass., and received his education from Kearney Grammar and High School and from Fawcett School of Industrial Arts, Newark, N. J., from which he was graduated.

He first came to Picatinny in November 1919 but remained only six months, returning in February 1921. He was on the staff of the Plant Engineering Division for the greater part of the time, and also spent a year in the Loading Department.

The following official order was issued by Lt. Col. J. K. Crain, Commanding Officer of the Arsenal.

"It is with extreme regret that the deaths of John Brainard Fidlar, Captain, Ord. Dept., Stephen Deevy, Assistant Mechanical Engineer and Frank Stevens, Jr., Explosives Operator, which occurred at Picatinny Arsenal in line of duty on March 21st, 1930, are announced.

"In the death of these men, the Ordnance Department as well as the United States Army loses a most efficient officer and two employees who were highly esteemed and trusted and never found wanting when duty called. The courage, steadfastness and devotion to duty up to the instant of death marked these men as those who have died in the furtherance of National Defense of this Nation, which we hold so dear. Their loss while engaged in performing their duty places upon those left behind a great obligation to carry on their uncompleted tasks."

Association Membership

THE Association has its government vested in a Board of Directors, six of whom are elected by general ballot of the entire membership, for terms of four years, and one director representing each local post, the latter being elected

by the respective posts. The officers, with one director elected by the Board of Directors, constitute the Board of Trustees which has the active management of the affairs of the Association. The President and Vice-Presidents are elected every two years by general ballot and the Counsel, Treasurer and Executive Secretary are appointed by the Board of Directors. The Association was incorporated in 1928 under the laws of the District of Columbia.

Over 90 per cent of the membership of the Association consists of executives and engineers of American industry who are cognizant of the importance of industrial preparedness. These gentlemen who, through affiliation with the Association are kept informed of current development of munitions, constitute a large portion of the civilian nucleus upon whom our Government will depend for the manufacture of ordnance in time of emergency.

The following extracts from the Constitution and By-Laws of the Association define the several classes of membership.

"Sec. 1. Full membership in the Association shall be open to all men who are American citizens and who are interested in promoting the cause of industrial preparedness, particularly in connection with the design, procurement, production, manufacture, inspection, test or supply of ordnance material.

"Sec. 2. Life membership in the Association shall be open to all men who are American citizens and who are interested in promoting the cause of industrial preparedness, particularly in connection with the design, procurement, production, manufacture, inspection, test or supply of ordnance material.

"Life membership shall continue during the lifetime of the life member and shall expire at death. It shall not be transferable.

"Sec. 3. Student membership in the Association shall be open to all men who are American citizens and who are students in technical schools or colleges. Student members shall not vote or hold office in the Association.

"Sec. 4. Group membership in the Association shall be open to all individuals, firms, companies and groups controlled by American citizens who are interested in promoting the cause of industrial preparedness, particularly in connection with the design, procurement, production, manufacture, inspection, test or supply of ordnance material.

"Group members shall have the privilege of nominating ten men for full membership in the Association, and members thus nominated shall pay no dues.

"Sec. 5. Honorary membership for life shall be conferred, in the discretion of the Board of Trustees, upon persons who have rendered meritorious service to the cause of industrial preparedness. Honorary members shall be entitled to all privileges of full membership except as otherwise provided in this Constitution and in the By-laws."

By-Laws

"5. The fee for life membership in the Association shall be One Hundred ($100.00) Dollars. The annual dues for membership in the Association shall be, for members, Five ($5.00) Dollars; for student members, Two Dollars and Twenty-five Cents ($2.25); and for group members, One Hundred ($100.00) Dollars, payable in advance. These sums are in addition to whatever dues or assessments may be imposed by the respective local posts in the case of members."

Deceased Members

SINCE publication of the last issue of Army Ordnance, National Headquarters has learned with regret of the death of the following members: Mervyn Ap Rice, Montclair, N. J.; James J. Campbell, Pittsburgh, Pa.; S. D. Deevy, Dover, N. J.; S. M. Felton, Chicago, Ill.; J. B. Fidlar, Dover, N. J.; Lyman N. Hine, New York, N. Y., and August H. Vogel, Milwaukee, Wis.

New Members

THE following have been admitted to membership in the Association since March 1, 1930: Rufus L. Adair, Jr., Providence, R. I.; A. Aigeltinger, New York, N. Y.; Charles Askins, Ames, Okla.; H. K. Babbitt, Wilmington, Del.; Bruce L. Bailey, Niagara Falls, N. Y.; W. R. G. Baker, Camden, N. J.; J. J. Bayer, Granite City, Ill.; Charles C. Black, Phila., Pa.; Harold C. Black, Morrisville, Pa.; Norman S. Blankenship, Wash., D. C.; R. C. Bodenhamer, El Dorado, Ark.; C. O. Bradley, Portsmouth, Va.; Albert S. Branson, Phila., Pa.; Rudolph S. Bresecka, New York, N. Y.; J. W. Burnison, Camden, N. J.; Kenneth F. Butte, San Francisco, Calif.; Joseph F. Carroll, Cleveland, Ohio; Lloyd Colston, South America; Burns C. Cox, Atlanta, Ga.; H. G. Curtis, Peoria, Ill.; John W. Davidge, Washington, D. C.; A. W. Daniels, Chicago, Ill.; Marshall S. David, Belmont, Mass.; Robert T. Dodd, New York, N. Y.; Charles S. Doran, Brooklyn, N. Y.; J. Marron Dundas, Washington, D. C.; George M. Enos, Cincinnati, Ohio; Joseph D. Evans, New York, N. Y.; John F. Ewert, Gloucester, N. J.; Nils Falk, New York, N. Y.; E. H. Flath, Dallas, Texas; E. L. Ford, San Francisco, Calif.; James Forrestal, Manhasset, New York; A. Stanley Fox, Cleveland, Ohio; Wayne Fox, Ventura, Calif.; Robert T. Gaines, Portsmouth, Va.; Harry Glaenzer, Philadelphia, Pa.; Edward Goerk, Cleveland, Ohio; L. Dwight Granger, New York, N. Y.; H. L. Grant, Jr., Latrobe, Penna.; E. C. Grimley, Camden, N. J.; Earl R. Groo, Ithaca, N. Y.; E. D. Gudebrod, Pottstown, Pa.; Mark R. M. Gwilliam, Brooklyn, N. Y.; Howard Hall, Cedar Rapids, Iowa; H. King Hathaway, New York, N. Y.; Lane W. Hildreth, Phila., Pa.; R. L. Hoadley, Macon, Miss.; Leonard I. Houghton, Springfield, Mass.; Samuel L. Huff, San Antonio, Texas; Samuel Jacobson, Chicago, Ill.; Michael Janchick, Chicago, Ill.; Frank J. Jervey, Washington, D. C.; George M. Johnson, Portsmouth, Va.; Charles A. Kanter, Detroit, Mich.; John P. Kelley, Milwaukee, Wisconsin; Willard W. Krauss, Buffalo, N. Y.; Fairman B. Lee, Seattle, Washington; Carl J. Marshall, East Milton, Mass.; George McQuilkin, Jr., Merchantsville, N. J.; Ward A. Miller, New York, N. Y.; Sterling Morton, Chicago, Ill.; Craig W. Muckle, Haverford, Pa.; Emil F. Norelius, Springfield, Ill.; Eyvind W. Petersen, Beloit, Wisconsin; A. S. Piques, Springfield, Mass.; Edw. A. Ravenscroft, Glencoe, Ill.; Edw. L. Sherwood, Ridgewood, N. J.; Carl P. Smith, Springfield, Ill.; C. W. Terry, Chicago, Ill.; Isaac W. Turner, White Plains, N. Y.; Horace S. Vaile, Chicago, Ill.; C. W. Woodworth, New York, N. Y.

ARMY ORDNANCE

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Month by Month

THE appointment of Lt. Col. Frederick H. Payne, Ord. Res., of Greenfield, Mass., as The Assistant Secretary of War will meet with the enthusiastic approval of all persons interested in the national defense. The Ordnance Department is to be congratulated that one who has served so conspicuously in its civilian component and who understands its problems so well has been placed in charge of the industrial activities of the War Department. The Army Ordnance Association, too, can take justifiable pride in the honor which has come to Colonel Payne who is a charter member of the organization.

The Assistant Secretary of War

An acknowledged leader in financial and industrial affairs of Massachusetts, the new Assistant Secretary served during the World War as a major in the Ordnance Department and as procurement officer of the Bridgeport Ordnance District. Later he was a member of the Claims Board of that district and returned to civil life in July, 1919. During the intervening years he has held a reserve commission of lieutenant colonel in the Ordnance Reserve Corps and has been of incalculable help in the work of the Bridgeport Ordnance District of which he is Assistant Chief. Until his appointment to the Assistant Secretaryship he was President of the Greenfield Tap and Die Corporation.

Colonel Payne, in a recent interview, summarized his attitude toward his new official status in these striking words: "There is no more important phase of military administration than that of assuring the Army adequate equipment and supplies at a minimum of notice."

We are confident that Colonel Payne, by virtue of his familiarity with the industrial aspects of military affairs and his demonstrated ability in this and commercial fields, will administer his important office to the satisfaction of his countrymen and thus add to the high regard in which he, personally, and his new activities are held.

ARMY ORDNANCE congratulates one of its own upon his acceptance of a patriotic task than which there is none more weighty and from the successful performance of which there should be no greater personal satisfaction.

SELDOM if ever has an organization of any kind observed its golden anniversary in better grace than did the American Society of Mechanical Engineers upon the occasion of the celebration of its fiftieth birthday on April 8, 1930. The sessions incident to the celebration, which culminated in the Nation's capital with the foundation of the Hoover Gold Medal and its first award to the distinguished engineer whose name it bears, were of so outstanding a character that they will make an indelible mark upon the progress of mechanical engineering the world over.

Fifty Years of Service

The A. S. M. E. richly deserves the enconiums which were showered upon it from every quarter of the globe. From the standpoint of national defense no scientific society has done more for the advancement of the mechanical engineering of munitions. The National Defense Division of the Society is a bulwark of engineering talent, a great reservoir of trained men who are not content to advance our country's engineering as applied to industry and creature comforts without always considering the possible application of peace-time mechanical progress to the Nation's needs in war.

While much praise attaches to those pioneers who founded the Society a half-century ago and to the men who, as officials, have guided it since, we take this opportunity to pay tribute to Lt. Col. Calvin H. Rice, Ord. Res., who has served as Secretary of the A. S. M. E. for many years. It is no exaggeration to say that the phenomenal growth of the Society in recent times is due in great measure to the efficient management of Colonel Rice. During his tenure there has existed the closest coöperation between his virile organization and the defense services, particularly the Ordnance Department of the Army. Through coöperative measures, a readiness to lend counsel and advice and a willingness to place at the disposal of the Department the vast brain-power resources of the National Defense Division, the Society under Colonel Rice's kindly interest has given and continues to give assistance of the first order to the mechanics of munitions.

The A. S. M. E. in its fiftieth year looks back upon a span of exceptional usefulness. Its future portends even greater things. There is every reason to be thankful for the splendid work of the Society for the national defense. The coming years will place greater emphasis on the machines of war, and as they come with their problems the American Society of Mechanical Engineers, through its National Division, will continue to assist in their prompt and efficient solution.

IN THESE columns of the March-April issue of ARMY ORDNANCE (Vol. X, No. 59, page 350) under the title, "Echoes of the Long-Range Gun," Col. Henry W. Miller, of Ann Arbor, Mich., author of the recent book, "The Paris Gun," was erroneously referred to as Col. Edward F. Miller, of Boston, Mass. The editorial nod became a coma in the resulting confusion. Luckily both Colonels Miller are lenient of editorial lapses and both have very graciously forgiven the unintentioned transgression.

Correction and Apologies

The following are the facts: Lt. Col. Henry W. Miller, Ord. Res. (B. S. 1907; M. E. 1910), author of "The Paris

Gun," is professor and head of the Department of Mechanism and Engineering Drawing, University of Michigan. From 1909 to 1912 he was in charge of the Department of General Engineering Drawing, University of Illinois; 1912-1917, Assistant Dean of the College of Engineering and head of the department of General Engineering Drawing of the same university. In 1917 he was commissioned a captain in the Ordnance Department and served in Washington in an engineering capacity on the design of railway carriages for heavy guns. As a major of Ordnance in 1918 he was an engineer for railway artillery of the American Expeditionary Forces, and from September, 1918, to July, 1919, having been promoted to the grade of lieutenant colonel, he was chief engineer for all heavy artillery of the A. E. F. From July, 1919, to August, 1920, he served in the Office of the Chief of Ordnance on the design of artillery and in the preparation of his well known texts and reference works: "Railway Artillery" (2 vols.), "American Seacoast Artillery" and "Mobile Artillery." His writings in addition to the above include "Descriptive Geometry," "Mechanical Drawing" and contributions to technical journals.

Col. Edward F. Miller, Ord. Res., to whom authorship of "The Paris Gun" was erroneously ascribed, is head of the Department of Mechanical Engineering at Massachusetts Institute of Technology. Since 1922 he has been dean of Army Officers attending M. I. T. and is a member of the faculty of the Ordnance School at the Watertown Arsenal. He is a director and past president of the Boston Post, Army Ordnance Association.

ARMY ORDNANCE regrets the error and hopes that the above correction with its apologies will help clear the record. The condoning fact, however, is that among ordnance devotees both Colonels Miller are so well known and admired for their splendid work in their respective fields that even an editorial blunder can detract but little.

THE article, "A New Weapon for Field Artillery," which appears in this issue of ARMY ORDNANCE, describes what to our mind is one of the revolutionary steps in the development of gunnery. An "all-purpose" field gun until now has been a thing sought but not attainable. Successfully to combine in one piece of field caliber the functions of ground and air defense, as the new weapon does, is nothing less than epoch-making. Hats-off to the Ordnance engineers who have produced this newcomer on the battle front!

The All-Purpose Gun Mount

There are many factors of recent progress which have been utilized in the new gun. Without the modern fire-control equipment the efficiency of the piece would not have been possible. Without recent metallurgical development permitting greater strength with no disproportionate increase in weight the all-purpose carriage would not have been practicable. Without the application of latest welding technique the construction would have been unsatisfactory. The entire weapon is but another indication that our ordnance experts are alive to the progress of the mechanical age in which we live and that no worthwhile application in any field of commercial practice is passed by until its possible use for the improvement of our armor is analyzed.

DISCUSSION of the general question of equitable and efficient measures for the prosecution of war continues to center interest in the action of the U. S. House of Representatives in sponsoring the Reed-Wainwright joint resolution for a study of principles and methods of "equalizing the burdens of war." *The Washington Post* recently presented the following excellent editorial analysis of the subject:

Equalizing the Burdens of War

"Ever since the World War there has been talk of drafting dollars as well as men in the next national emergency. Every one agrees to the principle that one group of men should not be allowed to remain home and grow wealthy while another group is at the front, facing death in a common cause. But there are many different ideas as to how industrial strength should be mobilized, and Congress has not given the matter sufficient attention to bring order out of these vague theories.

"The War Department is engaged in an extensive survey of industrial resources and plants which could be put to manufacturing war supplies whenever need arises. In many instances factories could be diverted to production of munitions and other supplies with little change of machinery. Every plant is charted according to its adaptability, so that war-time production would interfere only to a small degree with a factory's normal output. Industrial leaders realize that this method works to their advantage, and in most cases they are glad to coöperate with the Government in making whatever arrangements are necessary for industrial mobilization.

"There is before the military affairs committee of the Senate a resolution by Senator Reed, of Pennsylvania, providing for the appointment of a commission 'to study and consider the feasibility of equalizing the burdens and to minimize the profits of war, together with a study of policies to be pursued in event of war so as to empower the President immediately to mobilize all the resources of the country.' The commission would be composed of four senators, four representatives, the Secretaries of War, Navy, Agriculture, Commerce and Labor, and five other persons. As a logical sequel to the work that has been done by the War Department this commission should be appointed to advise Congress as to what action is necessary to coördinate all elements of national defense."

THOSE who have given thought to the subject realize that, if a worth-while knowledge of munitions is to be kept alive, the active interest of the present generation of engineering students is most important. The engineers of tomorrow upon whom the responsibilities of industrial preparedness will rest are the young men in the schools whose principal concerns now are the complexities of the slide rule, the diversities of sines and cosines, the solubility of sulphates or the pearlite proclivities of metals.

California Post Prize Essays

The California Post of the Army Ordnance Association sponsors each year a prize essay contest among the members of the Ordnance Units at the University of California, Stanford University and the University of Washington. The current contest is under way and ARMY ORDNANCE hopes to have the privilege of publishing at least the winning paper, and possibly the runner-up, in an early issue.

Aberdeen: An Object Lesson

An Editorial

THE Aberdeen Proving Ground—premier munitions testing ground so efficiently conducted by the Ordnance Department—was visited during the early part of May by some two hundred and forty odd cadets from the United States Military Academy, students of the course in Ordnance and Gunnery. They were on their annual pilgrimage to that great center to observe at close range the applied principles of armament construction and operation. As their predecessors at West Point have made similar tours of instruction and as countless leaders of American industry have made similar visits, so these future generals came to make perhaps their first intimate acquaintanceship with ordnance in the mass. That they spent a profitable, though all too brief, period at the proving ground is to be assumed for such is the almost universal experience of military and civilian visitors to that unique establishment.

The Aberdeen Proving Ground, like many another institution of established fame, is as much a tribute to the efficiency of the men who have been instrumental in bringing it to its present international renown as it is to the intrinsic worth of the ordnance developments which have been brought to fruition there.

WE believe that the function and prestige of Aberdeen are sufficiently known. Well located as a proving ground should be, it is easily accessible to the larger wartime munitions-producing centers. Other characteristics essential for its work, such as flat terrain, land and water ranges and remoteness, are ideal. Approximately 15 miles long and four miles wide, it contains nearly 35,000 acres. From the main firing front ranges up to 30,000 yards can be obtained, while from the "water battery," devoted to the test of railway and seacoast artillery, the same land range is available and there is also a water range up to 60,000 yards. There are special facilities for the testing of artillery and ammunition, tanks, tractors and motor gun carriages, a dynamometer laboratory for the test of gas engines and types of transmission and an oil laboratory for the test of lubricants. There is also a special small-arms range of 6,000 yards. Possibly nowhere else in the world is there such a concentration of types of armament. Aberdeen, in addition to its tremendous facilities, holds an unique position because of the matériel it has on display. There can be no finer place to acquaint our future Army Officers with the characteristics of weapons.

ALL this array of material things and size would be quite useless were the establishment not managed and operated by efficient personnel. Aberdeen has been extremely fortunate from the very first day, when it became the official successor of Sandy Hook, up to the present in having a corps of officers and civilian engineers which takes first rank among our national institutions. To handle the tremendous volume of work constantly going on at a testing ground of these proportions is a task which calls for the very best of administration and the finest of technical ability. Aberdeen now has, as it always has had, this efficiency and esprit in an unusual degree. That such is the case can be vouched for by the thousands who have visited the proving ground since its establishment to witness the demonstrations of ordnance matériel held there annually.

Current news dispatches indicate that Aberdeen is the center of a war game in which the ears of the Army are matched against the eyes in a series of unique antiaircraft artillery-Air Corps exercises. Army Air Corps bombardment and attack planes operating as a force are attacking the proving ground which is supposed to be an important giant airdrome and airport. The problem facing the defendants is to report movements of "enemy" aircraft in sufficient time for pursuit planes, antiaircraft batteries and searchlight units to frustrate attempted attacks.

"The object of the exercises," in the words of Assistant Secretary of War, F. Trubee Davison, is "to test local as well as distant intelligence service and communication by means of radio or telephone in joint defense of an airdrome by antiaircraft artillery and planes." With Aberdeen the center of attack and defense, the general situation, as outlined for the tests, extends as far south as the Potomac River. The exercises are divided into 17 distinct phases, each of which is designed to determine observation and intelligence efficiency. Some of the tests are conducted during daylight and others at night. No bombs, smoke screens or other chemicals are being used. Army officials expect that the lessons learned during the exercises will increase the high efficiency of our antiaircraft system as well as prove highly valuable to our air organization.

THE tactical lessons to be learned from such tests are many. In our judgment the most important object lesson is emphasis of the importance of the proving ground. It is not a far-fetched quirk of the imagination to picture Aberdeen thus attacked under actual war conditions. Should that ever happen and its defenses be insufficient, the Army would be deprived of the services of one of its most essential units. But after all, it is not only the material things which go with such an institution which are of value. There is the ability of the men behind the establishment which also must be reckoned with. Hence should Aberdeen ever be under fire of enemy weapons, it is a consoling thought to know that the talents of its officer and engineering staff are of the highest and that their work always could be carried on. While the proving ground shares the limelight, may we take occasion to pay public tribute to the officers, men and civilian employees who are its brains. They are responsible for a large portion of the efficiency of American armament, and post-war developments amply illustrate that they have done and are doing their work splendidly. It should be a source of pride to all persons interested in the national defense to know that Aberdeen, its plant and personnel, are so well equipped and efficiently managed. To the students of the Military Academy as well as the engineers of civil life it has lessons of great value. All should realize that, whether it falls to war-game attack or not, it is an institution of the first importance in the vast machinery of defense against war.

Professional Notes

The Viscosity of Cellulose

IN recent years considerable progress has been made in the utilization of cellulose and its derivatives for the production of artificial silks, lacquers, cellophane, etc. During some stage of the preparation of these products dispersion, or "solution", of the cellulose or derivative in some medium is necessary. The viscosity or fluidity of these dispersions under otherwise identical conditions has been found to vary with the cellulose used, and these variations in viscosity are of importance when the uses of the nitrated cellulose are considered. Accordingly, the effects of the viscosity of the cellulose on the processing and on the finished commercial materials have been carefully determined.

Attention has been given to the effects of variations in the viscosity of cellulose on the properties of nitrocellulose used in the manufacture of smokeless powders. As a result, the more recent specifications for cellulose have included some requirement for the viscosity of the material.

Although cellulose is not truly soluble in any known solvent, it has been found to form a colloidal dispersion with an ammoniacal copper solution, and the viscosity of a sample of cellulose is considered to be represented by the viscosity of a cuprammonium solution of such a sample. As the determination of this value is influenced by a number of factors, and no one method was in general use, the Cellulose Division of the American Chemical Society made a study of various methods and recommended a procedure which has been adopted by the Ordnance Department of the Army. (An outline of the method is given in the *Journal of Ind. Eng. Chem.*, Anal. Ed. *1*, 1929.)

The viscosity of cellulose is reduced by the action of either physical or chemical forces, e. g., heat, acidity, alkalinity, etc.; and the extent of the reduction depends upon the severity of the treatment. With the development of a suitable laboratory method for the determination of viscosity, better plant control of this property was made possible. At present this control is exercised by regulating the pressure (temperature) and time of the alkaline boiling treatment which is the chief feature of the purification of cotton linters. This method was thoroughly worked out at Woolwich Arsenal (*J. Soc. Chem. Ind. 39* 333T, 1929). More recently, a method for the reduction of the viscosity of cellulose by means of a controlled acid treatment which effects a relatively slight degradation of the cellulose, has been studied at Picatinny Arsenal (*Ind. Eng. Chem. 21*, 1178, 1929).

REDUCTION in the viscosity of cellulose may be considered as due to a reduction in the size of its colloidal or molecular aggregates and this physical change may involve chemical change as well. Since the reduction of viscosity by a given treatment, when plotted against time, may be represented by a hyperbolic curve, the decrease in rate with increase in time of treatment tends toward a product of greater uniformity with respect to viscosity as the treatment is continued.

The importance of the viscosity of cellulose to be used in the manufacture of nitrocellulose for smokeless powder is due to the fact that there is a definite relationship between the viscosity of the cellulose in cuprammonium and that of the nitrocellulose made from it and dissolved in ether-alcohol or acetone. Consequently, the amount of solvent required to form a nitrocellulose colloid, or gel, suitable for extrusion in powder-making is determined by the viscosity of the cotton linters. The lower the viscosity of the nitrocellulose the less the amount of solvent required for this purpose. Hence, if the lots of cellulose received for nitration are of markedly different viscosity, the nitrocellulose will vary in this property and the powder factory is faced with the difficulty of adjusting its procedure with each lot of nitrocellulose. Obviously, fairly close control of the viscosity of the raw material is desirable. This, in turn, should make for better control of grain size, as well as standardizing the drying period required to obtain the desired content of total volatiles.

H. Aaronson.
Picatinny Arsenal.

Improved Gas Masks for Horses

THE Field Artillery Board at Fort Bragg, North Carolina, has recently concluded a test of the new experimental gas masks for horses. When received by the Field Artillery Board, the masks were issued to the 2nd Battalion, 16th Field Artillery, and were used by horses of that organization thirty times between September 11, 1928, and November 1, 1929. The masks were on the horses for an average of two hours at each wearing and four hours was the maximum time of wearing.

As a result of the test it was found that when wearing these gas masks there was no appreciable effect on the endurance and efficiency of the horses while moving at a walk, but when trotting some animals had trouble breathing and became very warm, and all animals would cough after trotting a short distance. After the men and horses became accustomed to the use of the gas masks, the average time required to remove the mask from its carrier and adjust it to the animal's head was two and one-half minutes. The masks produced no chafing about the horses' heads and the bit and bridle did not interfere with the fit of the mask or its adjustment to the horse's head. Weather temperatures made no appreciable difference in breathing through the masks, but on a humid or wet day it was harder for the horses to breathe through the masks. All animals resisted being masked more than they resisted being bridled, but most of the horses became accustomed to being masked. Some few nervous animals, however, did not become so accustomed, and got irritable with repeated use of the masks. One mouth piece was badly chewed by a remount after about an hour and a half of wearing the mask. Under all conditions of weather temperature there was some foam and saliva in the masks when they were removed, but not enough to cause the animals any discomfort.

The Board recommended that if these gas masks give the required degree of protection against smoke and toxic gases they be adopted as standard after making some minor improvements.

Aerial Spotting for Big Guns Is Efficient

THE summary of results in spotting 448 shots during coast artillery target practice during 1929, at ranges from 10,000 to 17,500 yards, shows that the average error in estimating deviation to the right or left of the target was 53 yards for Air Corps observation and 45 yards for shore observation. In estimating "shorts" and "overs" the fliers called 93 per cent of them correctly as compared with an accuracy of 91 per cent by the shore observers.

The figures were obtained from records of target practices held in harbor defenses in the United States, Panama, Hawaii and the Philippine Islands and included firings from all calibers from 6-inch to 14-inch. The air observers at these practices flew in the vicinity of the target and reported the deviations of shots by radio to the battery firing where the data could be used for correcting the fire. Photographs taken of each shot from the towing boat and from shore enabled exact locations of the splashes for purposes of determining the number of hits and also the accuracy of spotting.

In transmitting the summary to the Chief of Air Corps, the commanding general commented on the excellence of the results attained and emphasized the importance of training in aerial spotting in order to utilize the full capabilities of our modern harbor defense guns at their extreme ranges.

New Tear Gas Device Developed

THE successful use of tear gas in quelling prison riots has resulted in great interest by prison authorities in this chemical agent which does its work without causing injury. This has caused requests for a tear gas device which immediately will produce a gas cloud of high concentration.

To meet this demand the Chemical Warfare Service of the Army has developed a universal fast-burning tear gas candle, which will produce an effective gas concentration so quickly that a rioter will be made helpless immediately. The fast-burning candles are used in the same manner as a grenade but differ from the latter in that they have a larger capacity and the tear gas is generated with almost explosive violence. Thus the gas gets into the air with no delay and in great volume.

The older grenades were somewhat slow in ignition and the gas was generated slowly. The fast-burning candle ignites so rapidly after leaving the hand that by the time it hits the ground it is giving off its fumes in great quantities. The test of these candles will be watched with greatest interest not only by the Army but by civil authorities, who agree that tear gas is a most effective and humane method of quelling riots and similar disturbances.

New Type of Field Wire for the Army

AFTER a number of years of study and experiment, the Signal Corps technical staff has recently completed the design, development and preliminary test of a new type of wire for portable field use that, it is hoped, will take the place of both the heavy and light types now issued and provide a better all-around wire for field telephone and telegraph communication.

The Signal Corps supplies wire of different types to the Army for communication purposes. That supplied to the combat branches for laying quickly on the ground to pro-

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vide communication within the division is, at present, of two types: a heavy insulated wire laid from horse—or motor— drawn vehicles and a lighter insulated wire laid by hand or from hand drawn vehicles.

The new type of wire (called field wire, type W-110) possesses high tensile strength and insulation, light weight and flexibility and when lying flat on the ground will successfully withstand considerable abrasion caused by passing vehicles, trampling by horses or men, or other abuse. Because of its lighter weight and decreased volume per mile, relatively larger amounts of the new type of wire can be transported and put on reels than was possible with the old type of heavy field wire.

Results of Air Corps Maneuvers

THE annual inventory period of the Army Air Corps, held this year at Mather Field, near Sacramento, California, has drawn to a close after four weeks of continuous flying activity.

From flights of units of three planes, to squadrons and groups, the training program expanded until it called for the coördination of nearly 130 combat planes operating as a complete wing and in simultaneous operation.

"We have had a most emphatic demonstration," said Assistant Secretary of War, F. Trubee Davison, "of our efficient training system as well as a graphic exhibition of the reliability and tactical value of modern military aircraft, not alone in operating against enemy aviation or ground troops but in coast defense as well.

"While the military attainments of the maneuvers are of compelling interest because they illustrate the efficiency of our air defenses, there are other phases of the demonstrations that are entitled to country-wide attention.

"There is, for instance, the marvelous feat of the 95th Pursuit Squadron in climbing in battle formation to almost 30,000 feet, thus pushing the fighting front of pursuit aviation more than 2 miles beyond World War combat altitudes. When we recall that only a couple of years ago 30,000 feet was a record height for one plane, with special equipment, to reach, we have a right to be proud and happy over the fact that the Army Air Corps has a service type of plane that enables 19 single-seaters to climb nearly 6 miles above ground as a matter of military routine. This quest for pursuit altitude is not a stunt but a grim necessity in aerial warfare. One may indeed truthfully say that so far as pursuit is concerned, altitude is strength."

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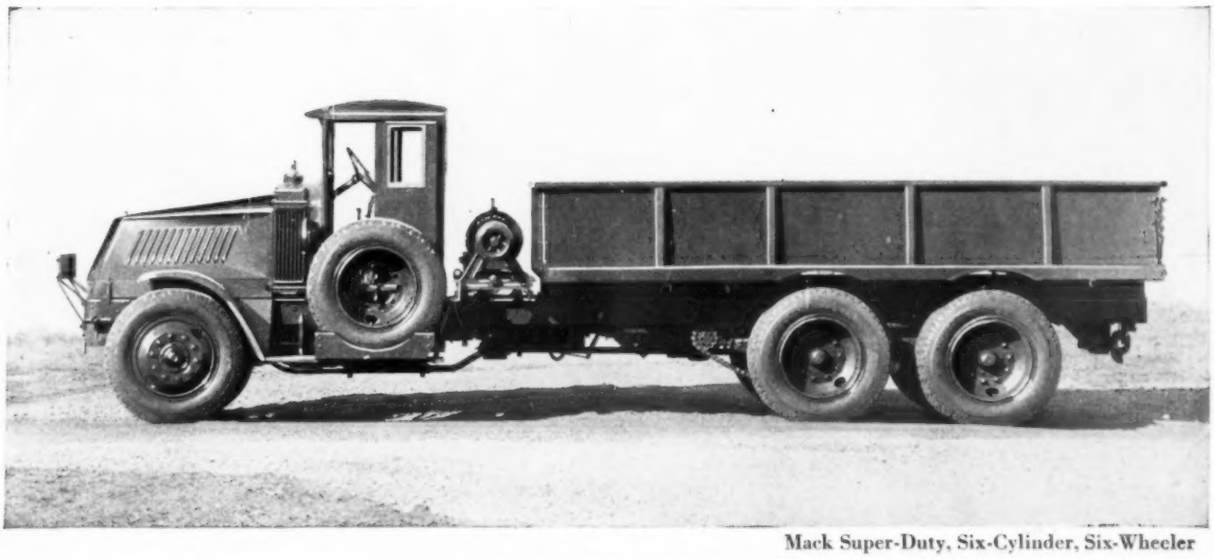

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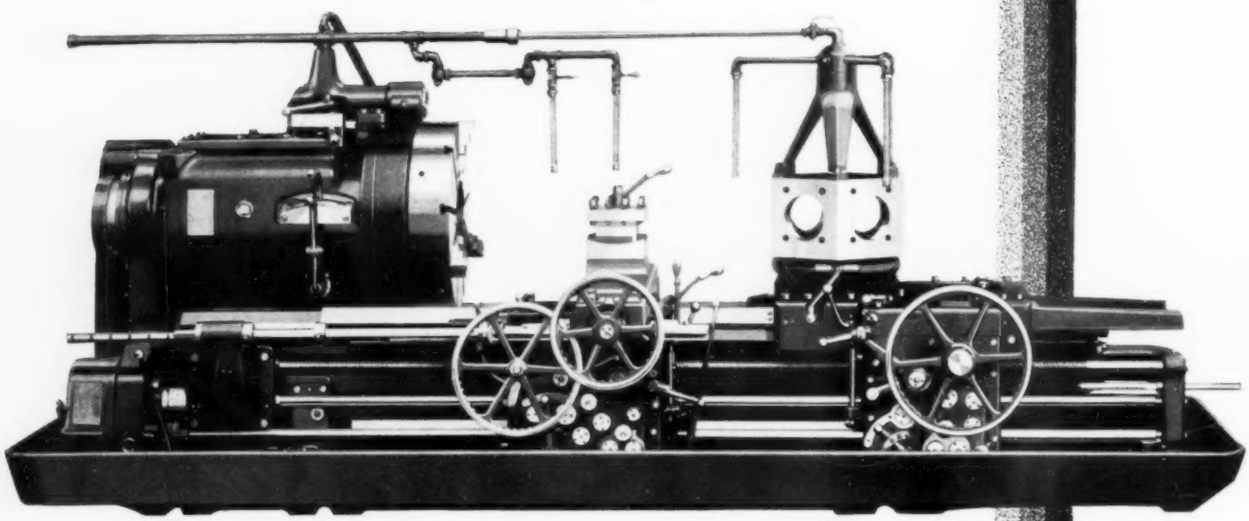

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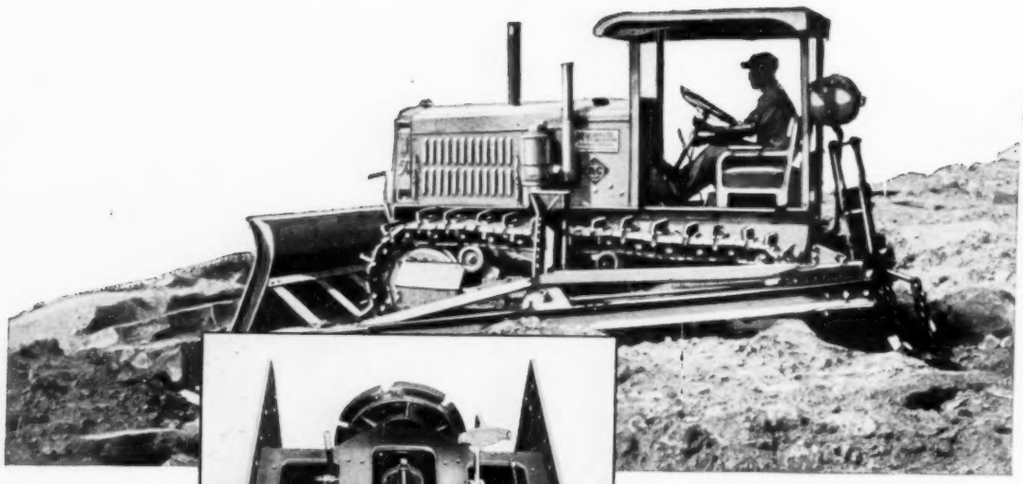

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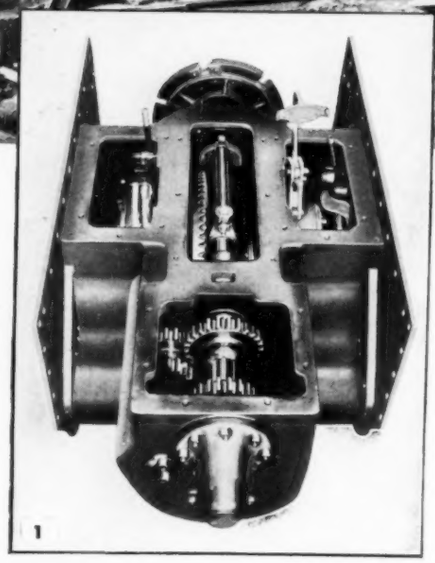
Monarch "50" Tractor with bulldozer attachment. Mfd. by ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. Lower illustrations show (1) transmission and (2) countershaft and reverse idler. All gears are 3½% Nickel, .20% carbon steel. Bevel pinion is 5% Nickel Steel S. A. E. 2512.



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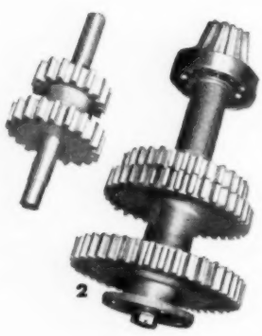

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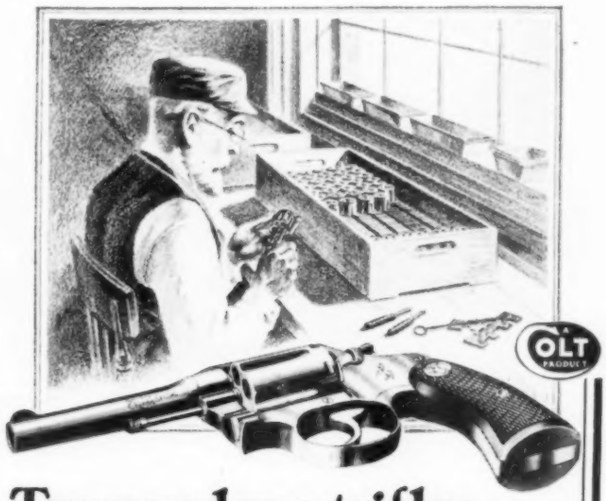

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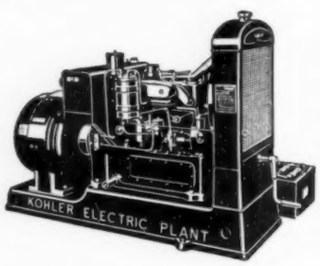

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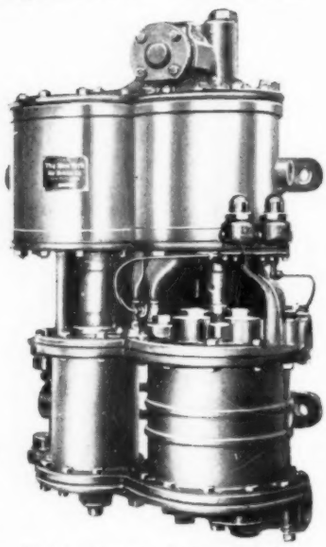

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CORROSION controlling alloy .... metals fearing neither the sting of caustics nor the bite of acids.

Tough, strong metals that can stand on their own feet in the construction of heavy equipment, yet cost little, if any more than less able materials.

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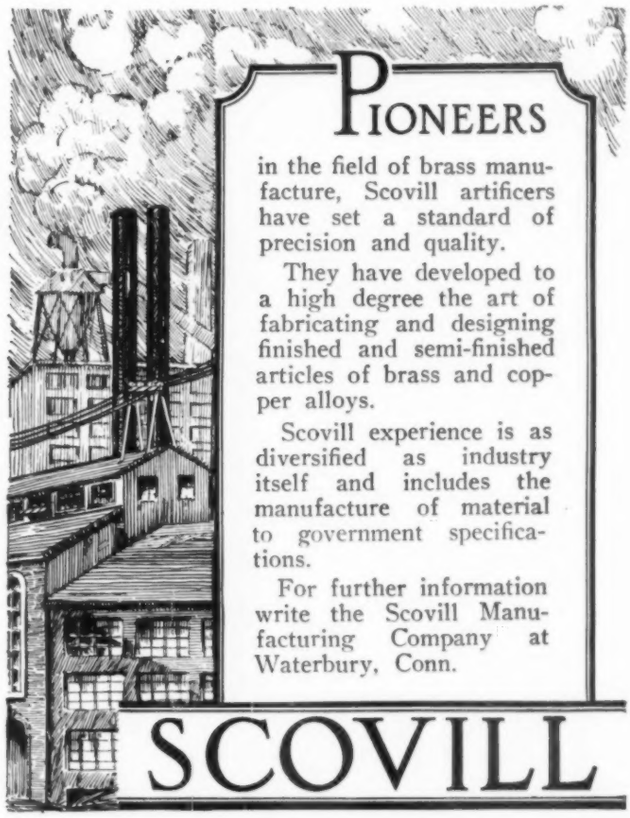

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The famous family of steel products under the Agathon trade-mark includes Alloy Steels, Special Finish Sheets as well as all standard finishes, Electrical Sheets, Hot Rolled Strip, Toncan Enameling Iron, Toncan Oven-Lining, Galvannealed Sheets and Enduro Stainless Iron.

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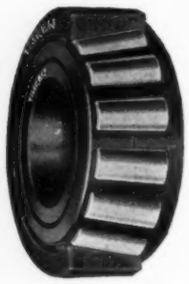
New York Newark Rochester Boston Philadelphia Pittsburgh Cincinnati Chicago Cleveland Detroit St. Louis Baltimore New Orleans Dallas San Francisco Los Angeles



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In every field of Transportation and throughout all Industry Timken Bearings have found universal acceptance. This follows the exclusive combination of Timken Tapered construction, Positively Aligned Rolls, and Timken Steel. In selecting equipment, look for Timken Bearings as proof of mechanical excellence.

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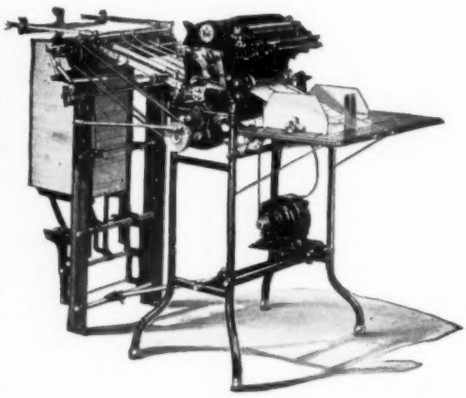

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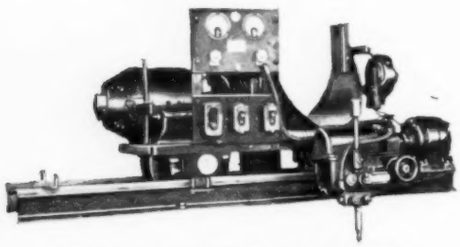

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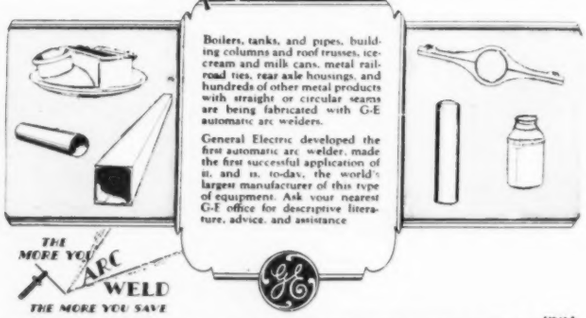
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General Electric developed the first automatic arc welder, made the first successful application of it, and is, to-day, the world's largest manufacturer of this type of equipment. Ask your nearest G-E office for descriptive literature, advice, and assistance
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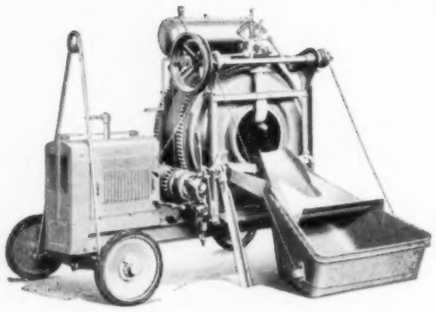

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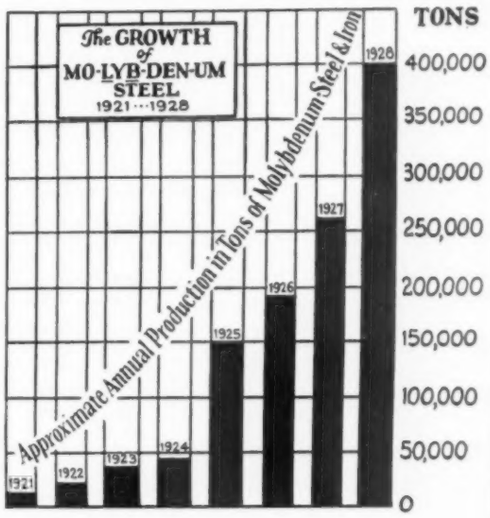

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"TIGER" Bronze Bushings and Solid Bars—in 12″ and 16″ lengths respectively—for long wearing maintenance part installation.

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THE Anaconda Trade-mark identifies copper and brass products in which the highest skill in manufacture is combined with the knowledge and experience of more than a century. A single organization controls the entire process of mining, smelting and manufacturing, thereby insuring the utmost in quality at every stage of production, from mining the ore to trade-marking the finished product.

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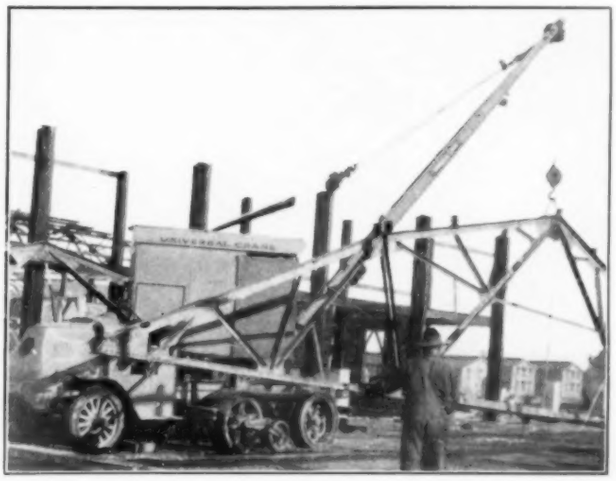

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Pictured above the U. S. A. Corps of Engineers at Ft. Humphries, Va., are erecting a steel building, with a Universal Crane mounted on a motor truck which is equipped with a Christie Crawler.

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Advantages of rear crawlers are easier steering, and faster travel without sacrifice of pulling power or bearing area.

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Portable Electric Tools

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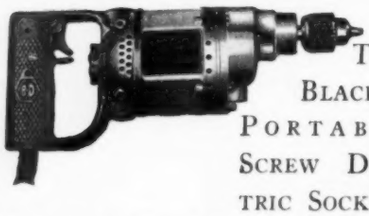

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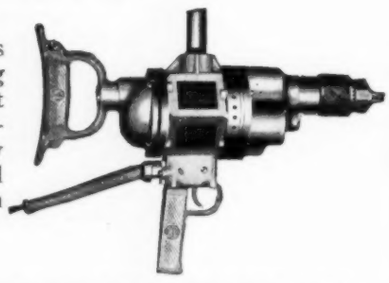
These tools are rendering the highest type of service in every civilized country in the world.



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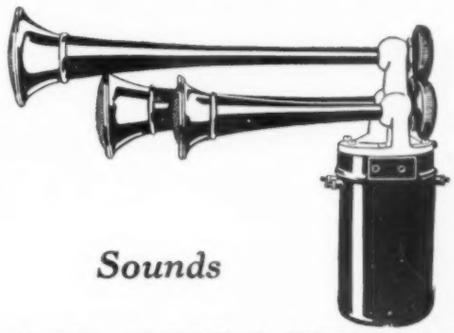

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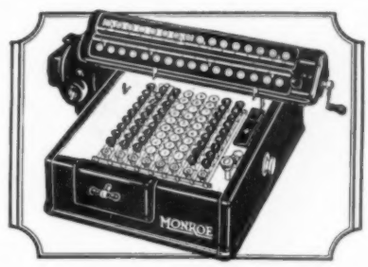

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HIGH SPEED ADDING-CALCULATOR

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Deck Ring Turret Liner Castings
Made of Vanadium Steel

THESE castings, made for Navy scout cruisers, are of acid open hearth steel. They have an inside diameter of approximately 22 feet, with weights varying from 9,000 to 13,340 pounds.

These castings were made of Vanadium Steel by the Penn Steel Castings Corporation to meet the following physical requirements:

Tensile Strength . . . . 85,000 Lbs. Per Sq. In.
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Wherever high physical properties are essential in steel castings for every service, Vanadium Cast Steel meets the requirements and renders dependable, satisfactory service.

Our Metallurgists will gladly send complete data on Vanadium Cast Steel and other Vanadium Alloy Steels. Write us today.

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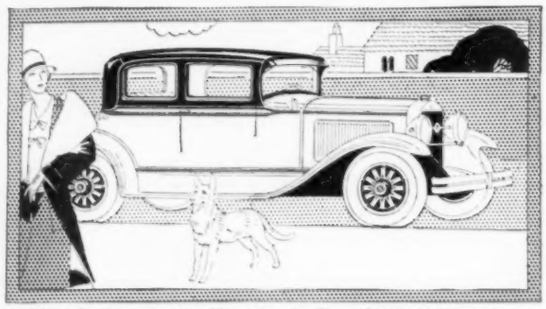
VANADIUM STEELS
for strength, toughness and durability



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Liquid Purification Plants
Benzol Recovery Plants
Motor Fuel Recovery Plants
Material Handling Plants
Ammonia Recovery Apparatus
Tar Distilling Plants
Gas Producers

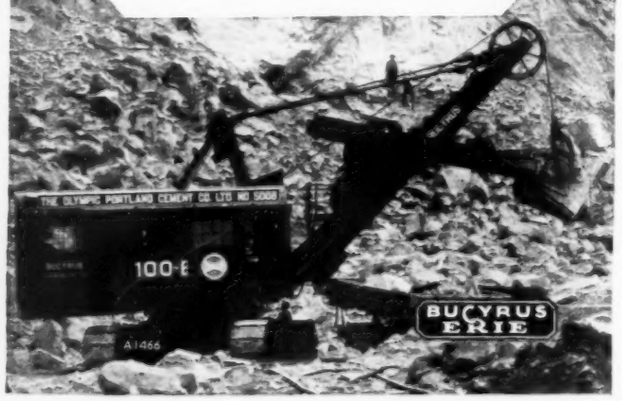
Consulting Engineers
on the operation of
BY-PRODUCT COKE AND GAS PLANTS
and their Auxiliaries

THE KOPPERS CONSTRUCTION CO.
PITTSBURGH NEW YORK CHICAGO

SMOOTH POSITIVE CONTROL

of the Bucyrus-Erie heavy duty quarry and mining shovels enables them to work swiftly—picking out the oversize, setting it behind for secondary blasting—loading cars evenly and without spilling, grading a level floor on which tracks can be easily laid. The sturdy machinery lasts longer and gives trouble-free operation because, even at their faster pace, these machines are not subjected to unnecessary jerks and vibration. The operator, sure of the accurate control under his finger tips, can push the machine harder and is as fresh and alert at the day's end as at its beginning. Investigate Bucyrus-Eries!

BUCYRUS-ERIE COMPANY
Head Office: So. Milwaukee, Wis.
Distributors in principal cities of U. S. A. and all parts of the world.



1855 · SEVENTY-FIFTH ANNIVERSARY · 1930

194 branches and sales offices are ready to co-operate on piping needs

Army buyers, stationed in San Francisco, San Antonio, New York, or anywhere else in the United States, when in need of plumbing or heating materials, will find a nearby Crane branch ready to give all information and co-operation.

For better service, both in buying and delivering, Crane Co. maintains 194 branches and sales offices, manned by experienced representatives. These will be especially pleased to assist army purchasers, whether they are seeking a fitting or faucet for a small repair job; plumbing and heating for a building; or a complete piping material layout for an engineering job as big as the Panama Canal.

Valves CRANE *Fittings*

CRANE CO., GENERAL OFFICES: 836 S. MICHIGAN AVENUE, CHICAGO
NEW YORK OFFICES: 23 WEST 44TH STREET
Branches and Sales Offices in One Hundred and Ninety-four Cities

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Selected by Important Scientific and Big Game Expeditions

When important scientific and big game expeditions start out for the untraveled portions of the world, with success frequently hinging upon the effectiveness of a single cartridge, they usually use Western ammunition.

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Highest quality Brass, Bronze, Phosphor Bronze, Nickle Silver; also special alloys for special purposes, supplied in rolls, sheets, strips, plates, circles. Stamped and drawn parts, fabricated from non-ferrous alloys and supplied to other manufacturers. Our technical men will gladly help solve your problems.

WESTERN CARTRIDGE COMPANY
East Alton, Ill., U. S. A.

Western Lubaloy
(LUBRICATING ALLOY)
Cartridges

Cletrac
Crawler Tractors

MODELS
20
30
40
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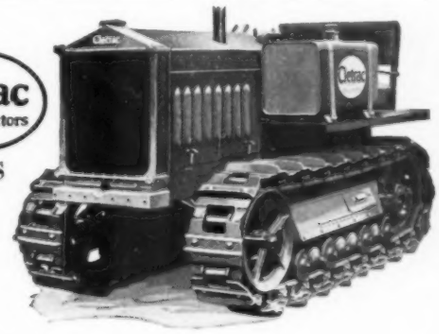


Cletrac

A Complete Line of

CRAWLER TRACTORS

for Every Type of Industrial Work

Cletracs offer greater power—positive traction over any footing—"One-Shot" oiling—speed and short turning—Year 'Round Utility.

Write for Catalog and Specifications

THE CLEVELAND TRACTOR CO., Cleveland, O.

. . . . for protecting metal surfaces—

EAGLE *Sublimed* BLUE LEAD

. . . . for all types of outside wood painting—

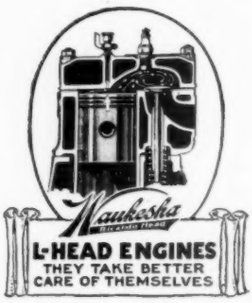
EAGLE *Pure* WHITE LEAD

THE EAGLE-PICHER LEAD COMPANY

Producers of Lead, Zinc and Allied Products

GENERAL OFFICES CHICAGO

Eleven Plants—Branches in Principal Cities



The Ricardo Head

—part and parcel of every Waukesha engine.

Its proportions, shape, and properly placed spark plugs eliminate "ping," increase turbulence, reduce unburned gases. The result—high compression, greater power, unusual economy.

There is no chance for lazy portions of the gas to hide in a pocket and flare up to cause after burning. Overheating, valve burning, loss of power—they are not to be found in a Waukesha engine.

WAUKESHA ENGINES

WAUKESHA WISCONSIN

SERVING *all arms of the service*

Batteries
Commercial Ranges, Ovens, and Broilers
Cozy Glow Heaters
Domestic Automatic Electric Ranges
Electric Fans
Electric Irons
Electric Water Systems
Floodlights
Interior and Exterior Lighting Fixtures
Lamps
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Percolators
Rectigon and Rectox Battery Chargers
Toasters
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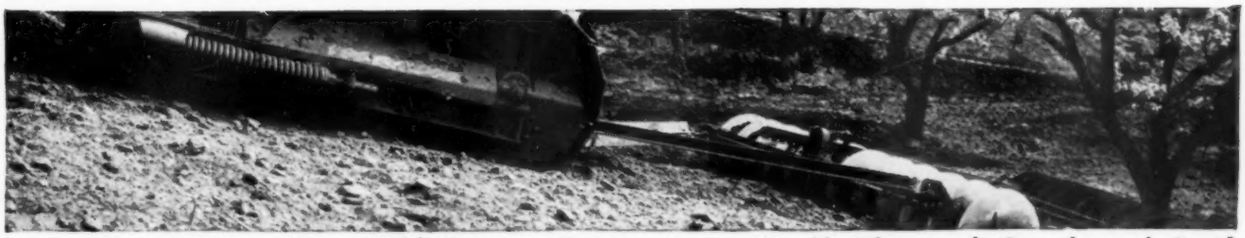
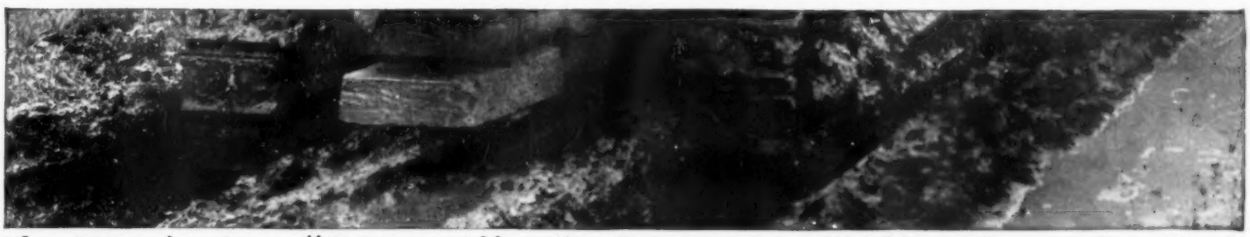


Sure Traction Up Hill Even On Loose, Well-Plowed Orchard Soil

Tracks That Find A Firm Foothold Even In Soft Blow Sand

The Load Is On Sleighs—"Caterpillar" Tracks Grip the Ice

Tracks That Wear But Slowly Even In Abrasive Dust and Grit



If Need Be "Caterpillar" Tractors Walk Through Mud

Made in five sizes for road-builder, farmer, logger, earth-mover and hauler.

Prices—f. o. b. Peoria, Illinois

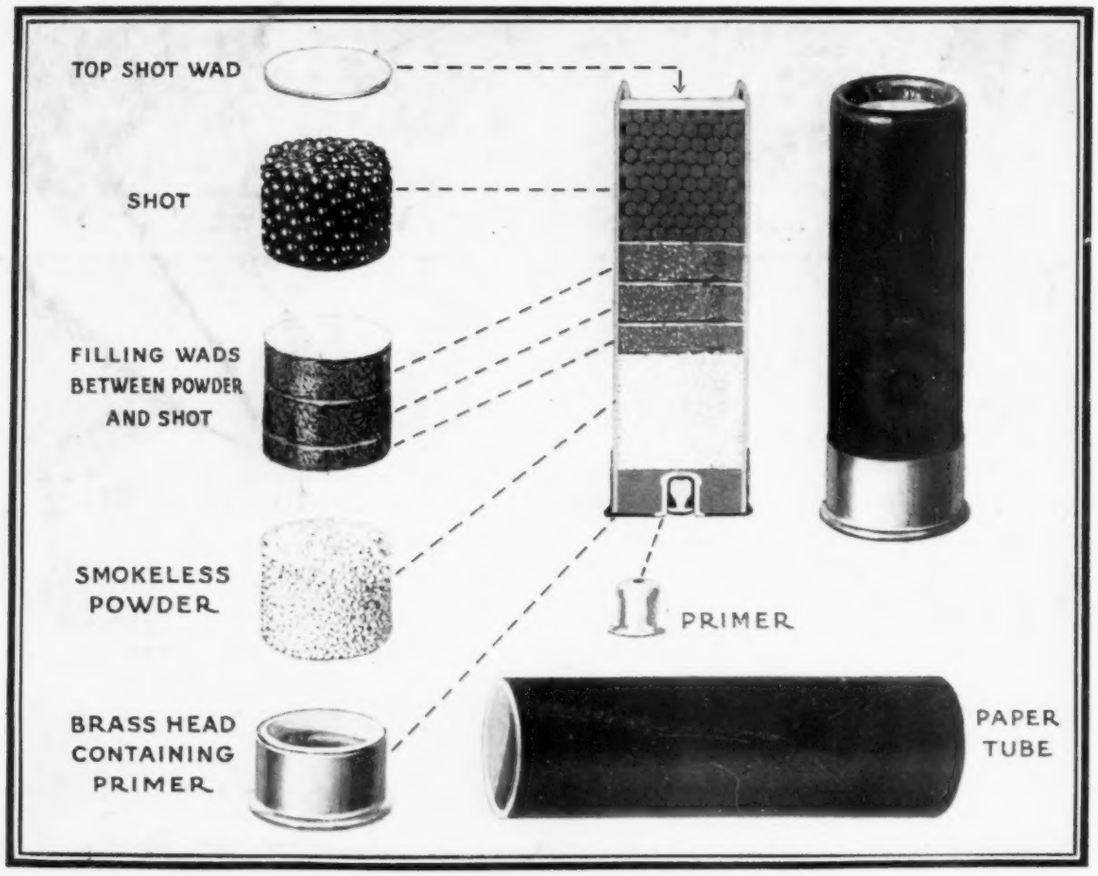
TEN	$1100	TWENTY	$1900
FIFTEEN	$1450	THIRTY	$2375
SIXTY	$4175		

Caterpillar Tractor Co.

PEORIA, ILL. *and* SAN LEANDRO, CALIF., U. S. A.
Track-type Tractors ⁄ Combines ⁄ Road Machinery
(There is a "Caterpillar" Dealer Near You)

CATERPILLAR
REG. U.S. PAT. OFF.
TRACTOR

NO. 1 OF A SERIES OF TALKS ON AMMUNITION QUALITY



What goes into your shot-shells?

OBVIOUSLY, what goes into your shot-shells determines their performance. The components required to make shotgun shells are by no means merely the tangible materials—shot, wads, powder, percussion cap and case. Even more important than the components are those intangible elements of experience and skill of employes, the knowledge of ballistic engineers, and the integrity and intelligence of the manufacturers.

We propose to outline in a series of advertisements —(this is the first)—the *intangible* but all-important elements determining the quality of the powder in the shells you buy. We shall take you, with the camera's assistance, through the laboratories of the du Pont Company. In these visits you may see how carefully the ultimate performances of du Pont Smokeless Shotgun Powders are definitely insured before they leave our powder mills, see how uniformity is guaranteed.

Du Pont powders are used by all of the principal ammunition manufacturers. They have selected du Pont powder because its ballistic qualities contribute so largely to the superiority of the ammunition, and the consequent success of its users. To maintain these standards of excellence, the ammunition companies will continue to load those powders ensuring the best ammunition possible for a specified purpose.

The du Pont Company, with its experiences of 126 years and its present resources, can supply to ammunition companies the type and quality of powders required to maintain the reputation of ammunition manufacturers and the confidence of the shooters.

DU PONT
REG. U. S. PAT. OFF.

E. I. du Pont de Nemours & Co., Inc., Smokeless Powder Department, Wilmington, Delaware.

SMOKELESS SHOTGUN POWDERS